Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not privide enough information to assess human radiation exposure from fallout, it is used as an alerting system for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form.

1. Radiation Surveillance Network December 1964

Division of Radiological Health, Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health, which regularly gathers samples from 75 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Alerting function

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to allow for decay of naturally-occurring radon daughters. The network station operators telephone any daily field estimates over 10 pc/m^3 to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C. Lower field estimates are reported to the Center by the laboratory at Rockville, Maryland, which receives a daily written report together with the air filter submitted by each station operator. The filters are counted at the laboratory to confirm field estimates.

Analyses for specific radionuclides may also be made if gross beta activity concentrations are high. All field estimates are reported elsewhere on a monthly basis (*1*). When unusually high air levels are reported, appropriate Federal and State officials are promptly notified.

Air sampling procedure and results

Airborne particulates are collected continuously on carbon-loaded cellulose dust filters 4 inches in diameter. A volume of about 1,800 cubic meters of air is drawn through each filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, where the gross beta activity is measured using a thin-window, gas-flow proportional counter, calibrated with a Sr^{90}–Y^{90} standard. Each filter is counted at least 3 days after the end of the sampling period and again 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-

FIGURE 1. RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*), the age of the fission products is estimated, and the activity extrapolated to the time of collection.[1] The daily concentrations and estimated ages of selected samples are reported by the PHS in a monthly RSN report (*1*).

The December *RSN* station average, maximum, and minimum gross beta activities in air are given in table 1. Figure 2 shows time profiles of data compiled since 1958 for eight of the stations.

Precipitation measurements

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nc/m², C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\overline{C}$, is determined by:

$$\overline{C} = \frac{\Sigma D}{\Sigma P} \times 1000$$

The December 1964 average concentrations and total depositions are given in table 1.

[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value; consequently the calculated age of the fresh component will be overestimated.

TABLE 1.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, DECEMBER 1964

Station location		Air surveillance					Precipitation measurement	
		Number of samples	Gross beta activity (pc/m³)			Last profile in *RHD*	Average concentration (pc/liter)[b]	Total deposition (nc/m²)[b]
			Maximum	Minimum	Average[a]			
Ala:	Montgomery	30	0.53	<0.10	0.20	Aug 64	113.4	22.8
Alaska:	Adak	23	0.59	<0.10	0.22	Nov 64		
	Anchorage	30	0.34	0.11	0.20	Apr 65	6.6	1.5
	Attu	22	0.22	<0.10	0.13	Dec 64		
	Fairbanks	8	0.23	<0.10	<0.14	Aug 64	7.1	1.4
	Juneau	4	0.21	<0.10	<0.13	Sep 64		
	Kodiak	18	1.04	<0.10	0.27	Oct 64		
	Nome	20	0.23	<0.10	<0.13	Feb 65		
	Point Barrow	26	0.22	<0.10	<0.13	Jan 65		
	St. Paul Island	30	0.47	<0.10	<0.19	Mar 65		
Ariz:	Phoenix	30	0.59	0.15	0.34	Sep 64		
Ark:	Little Rock	25	0.34	<0.10	0.18	Sep 64	89.3	18.1
Calif:	Berkeley	29	0.26	<0.10	<0.13	Oct 64	183.1	43.3
	Los Angeles	27	0.53	<0.10	0.24	Feb 65	45.6	9.4
Canal Zone:	Ancon	17	0.24	<0.10	<0.11	Nov 64		
Colo:	Denver	30	0.66	<0.10	0.25	Oct 64	9.1	1.8
Conn:	Hartford	29	0.41	<0.10	0.20	Oct 64	105.5	21.4
Del:	Dover	20	0.57	<0.10	0.24	Aug 64		
D. C:	Washington	28	0.53	<0.10	0.22	Feb 65	60.0	12.5
Fla:	Jacksonville	27	0.58	<0.10	0.26	Sep 64	119.1	24.9
	Miami	27	0.92	<0.10	0.37	Oct 64	79.1	16.0
Ga:	Atlanta	12	0.44	<0.10	<0.16	Apr 65	52.6	12.4
Guam:	Agana	30	0.64	<0.10	0.23	Apr 65		
Hawaii:	Honolulu	30	0.18	<0.10	<0.11	Dec 64	123.2	24.9
Idaho:	Boise	27	0.54	<0.10	<0.19	Dec 64	86.4	16.9
Ill:	Springfield	29	0.43	<0.10	0.21	Feb 65		
Ind:	Indianapolis	26	0.47	<0.10	0.19	Apr 65	86.9	17.6
Iowa:	Iowa City	29	0.46	0.11	0.25	Nov 64	29.8	6.8
Kans:	Topeka	28	0.37	<0.10	0.21	Jul 64	20.7	4.1
Ky:	Frankfort	30	0.50	<0.10	0.25	Feb 65	56.8	12.8
La:	New Orleans	28	0.44	<0.10	<0.18	Feb 65	74.1	14.9
Maine:	Augusta	31	0.68	<0.10	0.26	Mar 64	108.8	26.1
	Presque Isle	24	0.36	<0.10	<0.17	Nov 64		
Md:	Baltimore	27	0.45	<0.10	0.20	Oct 64	20.0	4.0
	Rockville	15	0.50	0.11	0.22	Jan 65		
Mass:	Lawrence	31	0.41	<0.10	0.20	Aug 64	52.0	13.0
	Winchester	27	0.66	<0.10	0.29	Dec 64	85.7	28.4
Mich:	Lansing	30	0.65	<0.10	0.29	Jan 65		
Minn:	Minneapolis	21	0.25	<0.10	0.15	Apr 65	29.0	6.2
Miss:	Jackson	29	0.44	<0.10	<0.20	Mar 65	199.8	40.8
	Pascagoula	10	0.32	<0.10	0.21	Dec 64		
Mo:	Jefferson City	28	0.37	<0.10	0.19	Apr 65	35.3	7.1
Mont:	Helena	29	0.45	<0.10	0.22	Nov 64	21.8	4.6
Nebr:	Lincoln	18	0.73	<0.10	0.32	Mar 65	11.3	3.8
Nev:	Las Vegas	24	0.56	<0.10	0.19	Aug 64		
N. H:	Concord	19	0.49	0.13	0.30	Feb 65		
N. J:	Trenton	31	0.70	<0.10	<0.22	Mar 65	31.8	7.4
N. Mex:	Santa Fe	22	0.28	<0.10	0.18	Nov 64	21.6	5.6
N. Y:	Albany	22	0.41	<0.10	0.21	Apr 65	59.4	11.9
	Buffalo	19	0.61	<0.10	0.27	Nov 64		
	New York	16	0.65	<0.10	0.26	Dec 64		
N. C:	Gastonia	25	0.53	<0.10	<0.24	Nov 64	83.9	17.0
N. Dak:	Bismarck	27	0.47	<0.10	0.19	Jan 65	16.3	3.7
Ohio:	Cincinnati	21	0.38	<0.10	0.18	Aug 64		
	Columbus	30	0.62	<0.10	0.30	Mar 65	86.5	22.9
	Painesville	30	0.66	<0.10	0.31	Oct 64	44.8	10.6
Okla:	Oklahoma City	30	0.38	<0.10	0.20	Jan 65		
	Ponca City	28	0.29	<0.10	<0.13	Oct 64	17.8	4.5
Ore:	Portland	28	0.85	<0.10	0.26	Mar 65	146.4	29.2
Pa:	Harrisburg	31	0.45	<0.10	<0.19	Apr 64	67.2	13.5
P. R:	San Juan	26	0.35	<0.10	<0.15	Mar 65	71.0	14.1
R. I:	Providence	30	0.42	<0.10	0.22	Jan 65	103.8	21.7
S. C:	Columbia	27	0.49	<0.10	<0.19	Dec 64	108.4	24.5
S. Dak:	Pierre	31	0.63	<0.10	0.23	Sep 64		
Tenn:	Nashville	30	0.61	<0.10	0.25	Jan 65	102.6	23.2
Tex:	Austin	31	0.36	<0.10	0.22	Aug 64	29.4	5.9
	El Paso	31	0.57	<0.10	0.31	Jan 65	11.5	2.3
Utah:	Salt Lake City	30	1.13	<0.10	0.32	Feb 65	84.7	18.4
Vt:	Barre	30	0.65	<0.10	0.32	Sep 64	72.2	15.0
		31	0.39	<0.10	<0.16	Sep 64	72.2	14.7
Va:	Richmond							
Wash:	Seattle	27	0.34	<0.10	<0.14	Jul 64	113.3	23.1
	Spokane	31	0.35	<0.10	<0.14	New		
W. Va:	Charleston	28	0.63	<0.10	0.26	Dec 64	68.2	20.0
Wis:	Madison	30	0.58	<0.10	0.25	Sep 64	7.0	3.7
Wyo:	Cheyenne	27	0.59	<0.10	0.22	Aug 64		
Network summary		1,786	1.13	<0.10	0.21		66.6	12.1

[a] The monthly average is calculated by weighting the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign appears before the average.

[b] Blank indicates no report received.

[c] For the network summary, all averages are arithmetic means of station averages.

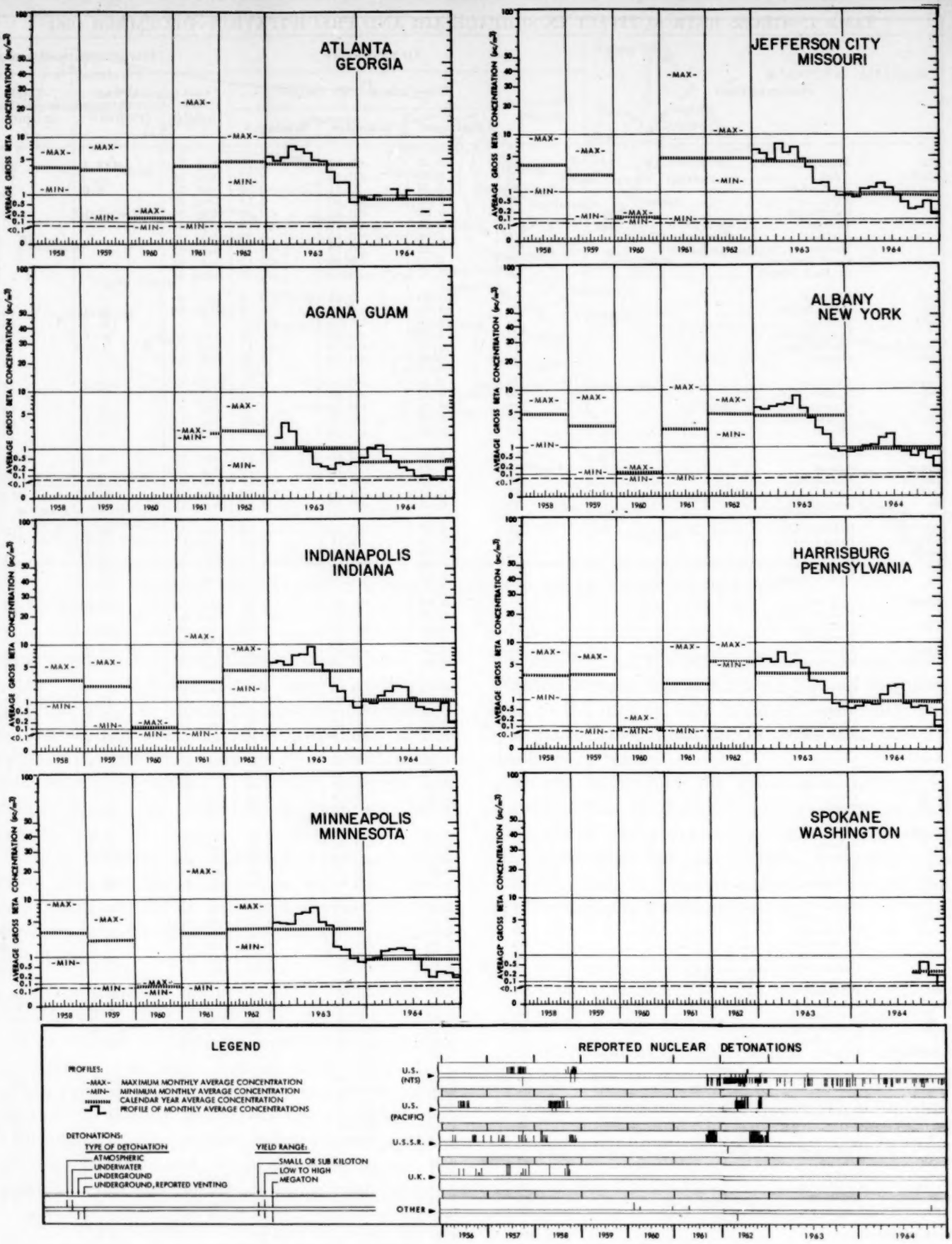

FIGURE 2. MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1958–DECEMBER 1964

2. National Air Sampling Network Fourth Quarter and Annual Summary 1964

Division of Air Pollution
Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. The NASN analyses air samples for the total quantity of suspended particulate matter, benzene-soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. These analyses aid in the detection of trends in levels of pollution with respect to time, location, population density, climate, and other factors.

Gross beta activity in air

NASN stations (see figure 3) are manned by cooperating Federal, State, and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 nonurban areas. In addition, there are stations in 130 cities which operate every other year. Thus, there are 240 sampling stations in all in the NASN network, of which 175 are active in any given year.

Continuous 24-hour samples of suspended particulate matter are taken at each station. The samples, representing approximately 2,000 cubic meters of air, are collected on glass fiber filters on a biweekly random sampling schedule. They are sent for analysis to the Network laboratory at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. Fourth quarter and annual summary 1964 data appear in tables 2 and 3.

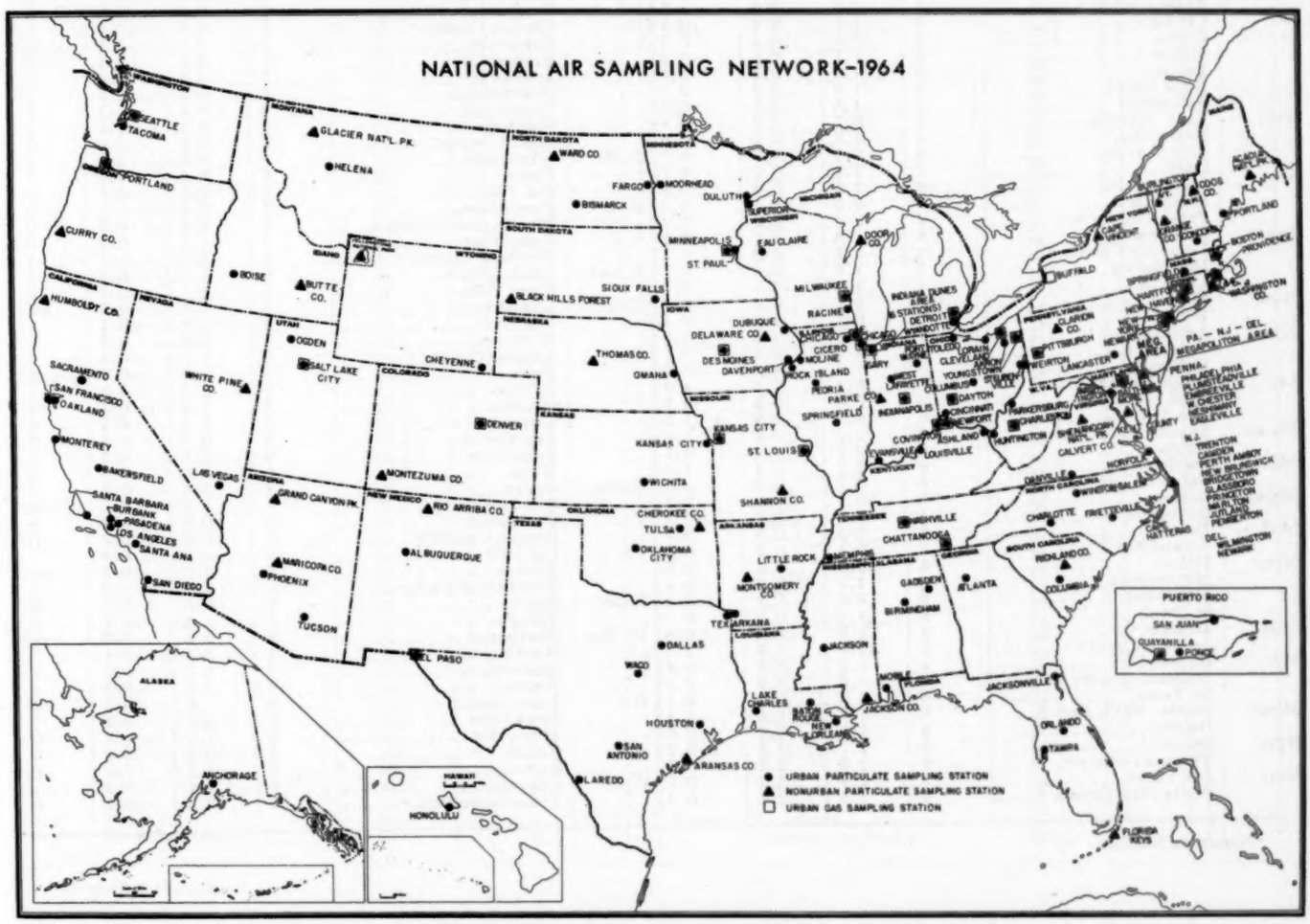

FIGURE 3. NATIONAL AIR SAMPLING NETWORK STATIONS, 1964

TABLE 2.—GROSS BETA ACTIVITY IN SURFACE AIR, NASN, FOURTH QUARTER, 1964

[Concentrations in pc/m³]

	Station	Number of samples	Maximum	Minimum	Average
Ala:	Birmingham	6	5.1	0.4	1.3
	Gadsden	6	2.9	0.4	1.0
	Mobile	6	9.3	0.2	2.0
Alaska:	Anchorage	5	0.4	0.1	0.3
Ariz:	Grand Canyon Pk.*	6	1.0	0.2	0.6
	Maricopa County *	6	1.2	0.3	0.8
	Phoenix	6	1.3	0.2	0.7
	Tucson	5	0.9	0.3	0.6
Ark:	Little Rock	6	2.5	0.1	0.8
	Montgomery County *	6	1.7	0.4	0.7
	Texarkana	6	2.4	0.2	0.7
Calif:	Bakersfield	6	1.3	0.2	0.6
	Burbank	5	0.9	0.3	0.5
	Humboldt County *	5	0.5	0.1	0.2
	Los Angeles	6	0.8	0.2	0.5
	Monterey	5	0.9	0.4	0.5
	Oakland	6	0.9	0.3	0.6
	Pasadena	6	1.1	0.2	0.5
	Sacramento	6	0.6	0.1	0.3
	San Diego	5	0.8	0.3	0.5
	San Francisco	6	0.9	0.1	0.5
	Santa Ana	6	0.7	0.1	0.4
	Santa Barbara	5	0.9	0.2	0.5
Colo:	Denver	6	9.5	0.2	1.9
	Montezuma County *	6	1.6	0.2	0.6
Conn:	Hartford	5	0.5	0.2	0.3
	New Haven	6	0.8	0.1	0.3
Del:	Kent County *	6	0.5	0.1	0.3
	Newark	6	0.6	0.2	0.4
	Wilmington	6	8.4	0.3	1.7
D. C:	Washington	6	7.2	0.1	1.4
Fla:	Florida Keys *	7	1.7	0.1	0.5
	Jacksonville	7	12.4	0.1	2.1
	Orlando	5	19.0	0.3	4.2
Ga:	Atlanta	6	3.8	0.4	1.2
Hawaii:	Honolulu	6	2.1	0.1	0.5
Idaho:	Boise	6	1.2	0.2	0.6
	Butte County *	6	4.0	0.4	1.6
Ill:	Chicago	6	1.5	0.2	0.5
	Cicero	5	0.5	0.2	0.3
	Moline	6	1.1	0.1	0.4
	Peoria	5	1.0	0.2	0.5
	Rock Island	6	1.8	0.3	0.7
	Springfield	6	1.5	0.3	0.6
Ind:	East Chicago	6	0.7	0.2	0.4
	Evansville	5	1.7	0.2	0.6
	Fort Wayne	6	2.4	0.2	0.7
	Gary	5	1.9	0.2	0.7
	Indianapolis	6	2.5	0.2	0.8
	Lafayette	5	0.6	0.1	0.3
	Parke County *	6	2.4	0.2	0.7
Iowa:	Davenport	6	1.8	0.1	0.6
	Delaware County *	6	1.2	0.2	0.5
	Des Moines	5	1.6	0.2	0.7
	Dubuque	6	1.4	0.3	0.7
Kans:	Kansas City	6	0.7	0.2	0.4
	Wichita	6	0.7	0.3	0.4
Ky:	Ashland	7	4.0	0.3	0.9
	Covington	6	4.2	0.1	1.1
	Louisville	5	1.3	0.2	0.6
La:	Baton Rouge	6	6.4	0.2	1.5
	Lake Charles	6	2.3	0.2	0.8
	New Orleans	6	6.8	0.3	1.6
Maine:	Acadia Nat'l. Park *	5	2.2	0.2	1.0
	Portland	6	2.7	0.2	0.7
Md:	Baltimore	6	3.7	0.3	1.0
	Calvert County *	6	5.7	0.2	1.2
Mass:	Boston	6	0.5	0.2	0.3
	Springfield	5	0.5	0.2	0.3
Mich:	Detroit	6	2.5	0.3	0.7
	Wyandotte	2	0.4	0.2	0.3
Minn:	Duluth	6	2.0	0.2	0.6
	Minneapolis	6	1.3	0.2	0.4
	Moorhead	6	0.8	0.2	0.4
	St. Paul	6	1.5	0.2	0.5
Miss:	Jackson	4	0.8	0.4	0.6
	Jackson County *	6	12.6	0.3	2.6
Mo:	Kansas City	6	0.6	0.2	0.4
	Shannon County *	6	3.0	0.2	0.9
	St. Louis	6	1.5	0.1	0.5
Mont:	Glacier Nat'l. Park *	6	1.1	0.1	0.4
	Helena	6	1.7	0.2	0.6
Nebr:	Omaha	6	2.7	0.2	0.9
	Thomas County *	6	2.9	0.2	0.8
Nev:	Las Vegas	6	1.4	0.3	0.7
	White Pine County *	6	1.3	0.1	0.5
N. H:	Concord	6	1.0	0.2	0.4
	Coos County *	6	2.1	0.2	0.6
N. J:	Bridgeton	6	0.7	0.2	0.4
	Camden	6	0.7	<0.1	0.4
	Jutland	5	0.6	0.1	0.4
	Marlton	6	1.6	0.1	0.5
	Newark	6	0.6	0.2	0.3
	New Brunswick	3	0.7	0.3	0.5
	Pemberton	5	0.6	0.2	0.4
	Perth Amboy	7	2.5	0.1	0.6
	Princeton	5	0.5	0.3	0.4
	Trenton	6	0.7	0.2	0.3
	Glassboro	5	0.8	0.2	0.4
N. Mex:	Albuquerque	6	2.1	0.2	0.8
	Rio Arriba County *	6	1.2	0.3	0.6
N. Y:	Cape Vincent *	6	1.4	0.2	0.5
	New York	6	0.9	0.2	0.5
N. C:	Cape Hatteras *	6	2.9	0.2	0.8
	Charlotte	6	3.2	0.3	0.9
	Fayetteville	6	6.2	0.1	1.3
	Winston Salem	6	5.1	0.3	1.2
N. Dak:	Bismarck	6	0.6	0.2	0.4
	Fargo	6	0.8	0.1	0.5
	Ward County *	7	0.7	0.1	0.3
Ohio:	Akron	6	4.4	0.1	1.1
	Cincinnati	5	2.9	0.4	1.0
	Cleveland	6	3.2	0.2	0.9
	Columbus	6	4.4	0.1	1.2
	Dayton	6	3.1	0.1	0.9
	Lorain	6	2.0	0.1	0.6
	Steubenville	6	4.0	0.1	1.0
	Toledo	6	2.6	0.2	0.8
	Youngstown	6	5.4	<0.1	1.2
Okla:	Cherokee County *	6	1.0	0.1	0.4
	Oklahoma City	7	0.8	0.2	0.5
	Tulsa	6	1.9	0.2	0.6
Ore:	Curry County *	6	0.9	0.1	0.3
	Portland	6	0.9	0.1	0.4
Pa:	Clarion County *	7	6.3	<0.1	1.2
	Eagleville	4	0.5	0.2	0.4
	Embreeville	6	0.5	0.1	0.3
	Lancaster	7	3.4	0.1	0.8
	Philadelphia	5	0.9	0.2	0.5
	Pittsburgh	6	6.1	0.1	1.3
	Sanatoga	2	0.3	0.1	0.2
	West Chester	2	0.2	0.1	0.2
P. R:	Guayanilla	7	0.5	0.1	0.2
	Ponce	6	0.5	0.1	0.2
	San Juan	6	0.3	0.1	0.2
R. I:	Providence	7	2.2	0.2	0.6
	Washington County *	6	0.7	0.2	0.4
S. C:	Columbia	5	1.7	0.1	0.9
	Richland County *	5	5.1	0.1	1.2
S. Dak:	Black Hills *	6	3.9	0.3	1.4
	Sioux Falls	6	2.1	0.1	0.5
Tenn:	Chattanooga	5	3.1	0.3	1.1
	Memphis	6	3.4	<0.1	1.2
	Nashville	6	2.5	0.3	0.8
Tex:	Aransas County *	6	1.7	0.1	0.6
	Dallas	6	1.9	0.3	0.8
	El Paso	6	2.5	0.3	1.0
	Houston	6	1.9	0.3	0.7
	Laredo	4	1.1	0.2	0.5
	San Antonio	6	0.7	0.1	0.5
	Texarkana	6	2.1	0.2	0.7
	Waco	6	0.9	0.4	0.6
Utah:	Ogden	7	3.4	0.1	1.0
	Salt Lake City	5	1.7	0.1	0.7
Vt:	Burlington	5	0.8	0.2	0.4
	Orange County *	6	1.2	0.2	0.4
Va:	Danville	6	5.2	0.4	1.2
	Norfolk	6	4.7	0.2	1.1
	Shenandoah Park *	7	9.8	0.3	1.8
Wash:	Seattle	6	0.5	0.1	0.2
	Tacoma	6	0.6	0.1	0.3
W. Va:	Charleston	6	2.6	0.2	0.9
	Huntington	6	3.3	0.4	1.0
	Parkersburg	6	4.7	0.1	1.0
	Weirton	6	1.6	0.1	0.6
Wis:	Door County *	5	1.8	0.3	0.7
	Eau Claire	6	1.7	0.2	0.5
	Milwaukee	6	1.2	0.3	0.5
	Racine	6	0.8	0.2	0.4
	Superior	6	1.7	0.2	0.5
Wyo:	Cheyenne	6	4.1	0.2	1.0
	Yellowstone Park *	6	2.8	0.1	0.7

* Nonurban Stations

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, ANNUAL SUMMARY, 1964

[Concentrations in pc/m³]

	Station	Number of samples	Maximum	Minimum	Average
Ala:	Birmingham	26	5.1	0.1	1.4
	Gadsden	26	3.3	0.1	1.3
	Mobile	26	9.3	0.2	1.7
Alaska:	Anchorage	24	3.8	0.1	0.7
Ariz:	Grand Canyon Pk.*	25	5.0	0.2	1.7
	Maricopa County *	26	8.0	0.1	2.4
	Phoenix	26	5.4	0.1	2.0
	Tucson	25	6.5	0.1	1.8
Ark:	Little Rock	25	3.6	0.1	1.2
	Montgomery County *	24	5.5	0.3	1.6
	Texarkana	24	2.9	0.1	1.1
Calif:	Bakersfield	25	5.6	0.2	1.5
	Burbank	24	6.5	0.3	1.7
	Humboldt County *	23	3.0	0.1	0.5
	Los Angeles	26	4.7	0.2	1.2
	Monterey	22	3.6	0.2	1.1
	Oakland	25	3.6	0.1	0.9
	Pasadena	26	5.0	0.2	1.6
	Sacramento	26	4.9	0.1	1.1
	San Diego	25	4.0	0.3	1.5
	San Francisco	26	3.3	<0.1	0.9
	Santa Ana	25	3.2	0.1	1.2
	Santa Barbara	26	4.0	0.2	1.1
Colo:	Denver	26	9.5	0.2	2.0
	Montezuma County *	26	5.7	0.2	1.6
Conn:	Hartford	23	3.5	0.1	1.4
	New Haven	26	4.9	0.1	1.3
Del:	Kent County *	23	4.4	0.1	1.3
	Newark	16	3.7	0.2	1.1
	Wilmington	26	8.4	0.3	1.7
D. C:	Washington	26	7.2	<0.1	1.6
Fla:	Florida Keys *	21	4.1	0.1	1.3
	Jacksonville	26	12.4	0.1	1.7
	Orlando	20	19.0	0.3	2.6
	Tampa	19	5.7	0.1	2.2
Ga:	Atlanta	26	3.8	0.2	1.4
Hawaii:	Honolulu	26	2.2	0.1	0.8
Idaho:	Boise	26	4.2	0.2	1.5
	Butte County *	26	5.5	0.4	1.8
Ill:	Chicago	21	3.2	0.1	1.1
	Cicero	21	4.0	0.2	1.4
	Moline	24	3.4	0.1	1.1
	Peoria	23	2.7	0.2	1.1
	Rock Island	24	4.6	0.3	1.7
	Springfield	15	1.8	0.3	0.7
Ind:	East Chicago	23	2.4	0.2	1.0
	Evansville	23	3.9	0.2	1.3
	Fort Wayne	25	4.1	0.2	1.5
	Gary	21	3.7	0.2	1.4
	Indianapolis	26	3.8	0.2	1.5
	Lafayette	22	2.5	0.1	1.1
	Parke County *	26	2.9	0.2	1.2
Iowa:	Davenport	23	3.1	0.1	1.3
	Delaware County *	24	2.3	0.2	1.0
	Des Moines	25	3.6	0.2	1.5
	Dubuque	26	2.8	0.1	1.2
Kans:	Kansas City	25	3.3	0.2	1.1
	Wichita	25	3.8	0.3	1.3
Ky:	Ashland	24	6.5	0.3	1.7
	Covington	24	5.7	0.1	1.6
	Louisville	21	3.0	0.2	1.2
La:	Baton Rouge	26	6.4	<0.1	1.4
	Lake Charles	26	3.4	<0.1	1.1
	New Orleans	26	6.8	0.1	1.6
Maine:	Acadia Nat'l. Park *	23	3.9	0.2	1.4
	Portland	24	3.5	0.2	1.3
Md:	Baltimore	24	4.6	0.2	1.5
	Calvert County *	26	5.7	0.2	1.7
Mass:	Boston	26	4.4	0.2	1.3
	Springfield	24	3.8	0.1	1.2
Mich:	Detroit	26	4.3	0.3	1.4
	Wyandotte	18	4.7	0.2	1.8
Minn:	Duluth	25	2.7	0.2	1.1
	Minneapolis	26	2.7	0.1	1.0
	Moorhead	25	3.2	0.2	1.2
	St. Paul	26	2.6	0.1	1.1
Miss:	Jackson	24	3.3	<0.1	1.3
	Jackson County *	20	12.6	0.1	1.7
Mo:	Kansas City	25	4.2	0.2	1.4
	Shannon County *	25	3.6	0.1	1.7
	St. Louis	26	3.1	0.1	1.2
Mont:	Glacier Nat'l. Park *	24	2.5	0.1	0.8
	Helena	26	4.7	0.1	1.3
Nebr:	Omaha	26	4.3	0.1	1.7
	Thomas County *	24	6.4	0.2	1.6
Nev:	Las Vegas	25	4.9	0.2	1.8
	White Pine County *	23	4.6	0.1	1.5
N. H:	Concord	24	3.3	0.1	1.2
	Coos County *	25	3.4	0.1	1.2
N. J:	Bridgeton	14	4.2	<0.1	1.0
	Camden	26	4.6	<0.1	1.5
	Jutland	20	4.2	0.1	1.6
	Marlton	18	5.8	0.1	1.6
	Newark	26	3.8	0.2	1.3
	New Brunswick	22	3.5	0.1	1.4
	Pemberton	18	4.4	<0.1	1.3
	Perth Amboy	20	5.2	<0.1	1.4
	Princeton	18	3.8	0.3	1.4
	Trenton	22	3.3	0.1	1.1
	Glassboro	23	4.5	0.2	1.5
N. Mex:	Albuquerque	26	5.8	0.1	1.8
	Rio Arriba County *	26	4.9	0.3	1.8
N. Y:	Cape Vincent *	26	3.2	0.2	1.2
	New York	26	5.7	0.2	1.4
N. C:	Cape Hatteras *	25	6.4	0.1	1.5
	Charlotte	25	4.1	0.1	1.3
	Fayetteville	24	6.2	0.1	1.8
	Winston Salem	25	5.1	0.2	1.6
N. Dak:	Bismarck	26	6.1	0.2	1.4
	Fargo	25	3.3	0.1	1.2
	Ward County *	26	5.3	0.1	1.3
Ohio:	Akron	26	4.4	0.1	1.5
	Cincinnati	25	6.0	0.3	1.8
	Cleveland	26	3.2	0.2	1.3
	Columbus	26	6.5	0.1	1.6
	Dayton	26	6.8	0.1	1.6
	Lorain	25	3.1	0.1	1.2
	Steubenville	24	4.0	0.1	1.4
	Toledo	26	6.5	0.1	1.6
	Youngstown	26	5.4	<0.1	1.5
Okla:	Cherokee County *	26	5.0	0.1	1.3
	Oklahoma City	25	4.6	0.2	1.4
	Tulsa	26	3.9	0.1	1.3
Ore:	Curry County *	19	1.5	0.1	0.4
	Portland	25	3.5	0.1	0.8
Pa:	Clarion County *	22	6.3		1.4
	Embreeville	19	3.4	0.1	1.0
	Lancaster	25	4.5	0.1	1.5
	Philadelphia	25	4.4	<0.1	1.5
	Pittsburgh	26	6.1	0.1	1.5
P. R:	Guayanilla	26	3.3	0.1	1.0
	Ponce	26	3.2	0.1	1.1
	San Juan	25	3.2	0.1	1.0
R. I:	Providence	23	4.0		1.3
	Washington County *	26	5.1	0.1	1.5
S. C:	Columbia	21	4.6	0.1	1.5
	Richland County *	23	5.1	0.1	1.5
S. Dak:	Black Hills *	26	4.9	0.3	1.8
	Sioux Falls	25	2.5	0.1	1.2
Tenn:	Chattanooga	24	5.1	0.3	1.5
	Memphis	24	5.7	<0.1	1.6
	Nashville	26	3.5	<0.1	1.4
Tex:	Aransas County *	26	3.1	<0.1	1.3
	Dallas	26	3.2	0.1	1.3
	El Paso	26	8.3	0.1	2.3
	Houston	24	4.5	<0.1	1.2
	Laredo	19	5.2	<0.1	0.9
	San Antonio	25	5.1	0.1	1.4
	Texarkana	24	3.8	0.1	1.2
	Waco	26	3.9	0.2	1.3
Utah:	Ogden	26	3.4	0.1	1.6
	Salt Lake City	24	5.2	0.1	1.7
Vt:	Burlington	23	4.2	0.1	1.2
	Orange County *	26	3.1	0.1	1.2
Va:	Danville	25	6.1	0.2	1.9
	Norfolk	26	5.6	0.2	1.7
	Shenandoah Park *	26	9.8	0.3	1.7
Wash:	Seattle	26	1.7	0.1	0.5
	Tacoma	25	1.9	0.1	0.6
W. Va:	Charleston	26	5.2	0.1	1.5
	Huntington	24	6.8	<0.1	1.7
	Parkersburg	26	6.3	0.1	1.6
	Weirton	21	4.2	0.1	1.5
Wis:	Door County *	23	2.9	0.2	1.3
	Eau Claire	26	3.1	0.2	1.3
	Milwaukee	26	3.5	0.3	1.2
	Racine	26	2.7	0.2	1.1
	Superior	24	2.2	0.1	0.9
Wyo:	Cheyenne	25	5.4	0.2	1.7
	Yellowstone Park *	26	3.0	0.1	1.2

* Nonurban stations.

3. Canadian Air Monitoring Program[2] December 1964

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 4), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter glass fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas-flow, Geiger-Mueller counter system calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for December 1964 are given in table 4.

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450 degrees C. The ash is combined with the soluble fraction, transferred to a glass planchet,

[2] Data from RADIATION PROTECTION DIVISION. *Radiation Protection Programs*, Vol. 3, No. 1: 45–46 (January 1965), Canadian Department of National Health and Welfare, Ottawa, Canada.

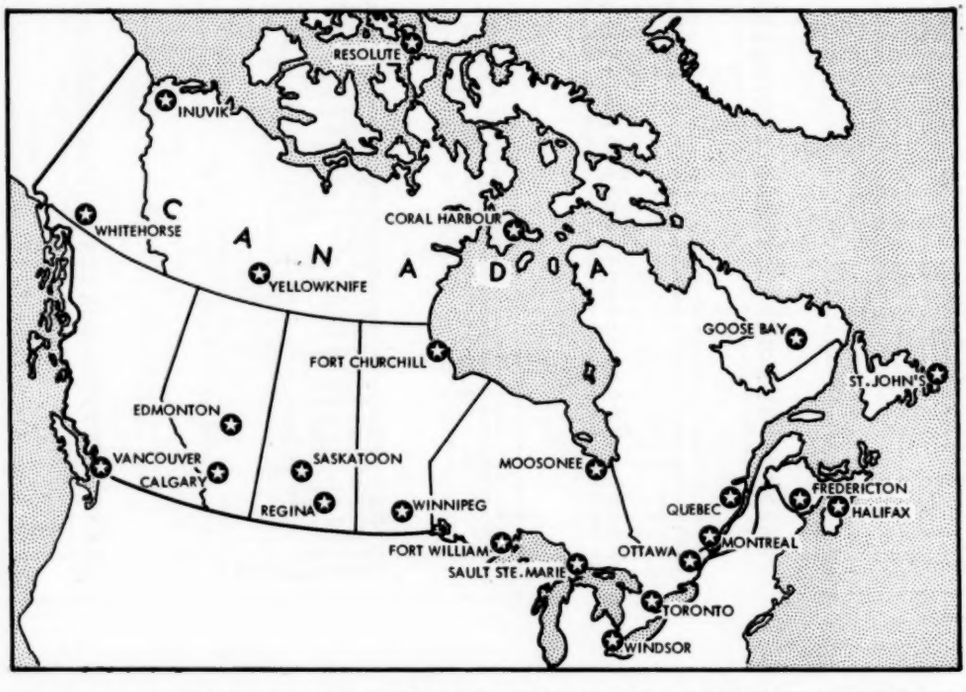

FIGURE 4. CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

TABLE 4.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, CANADA, DECEMBER 1964

Station location	Air surveillance				Precipitation measurements	
	Number of samples	Gross beta activity (pc/m³)			Average concentration (pc/liter)	Total deposition (nc/m²)
		Maximum	Minimum	Average		
Calgary	31	0.5	0.1	0.3	96	2.3
Coral Harbour	29	0.3	0.1	0.2	80	0.9
Edmonton	31	0.4	0.1	0.3	162	3.0
Ft. Churchill	30	0.3	0.1	0.2	trace	1.2
Ft. William	31	0.4	0.2	0.2	120	5.1
Fredericton	31	0.3	0.0	0.1	33	5.8
Goose Bay	31	0.4	0.0	0.2	78	4.2
Halifax	21	0.3	0.0	0.2	57	11.4
Inuvik	31	0.5	0.2	0.3	69	2.0
Montreal	31	0.4	0.1	0.2	125	9.4
Moosonee	31	0.3	0.1	0.2	68	2.5
Ottawa	30	0.3	0.1	0.2	74	5.2
Quebec	31	0.4	0.1	0.2	100	11.7
Regina	31	0.4	0.1	0.2	95	2.1
Resolute	30	0.4	0.1	0.2	356	3.6
St. John's, Nfld	26	0.4	0.0	0.2	54	9.4
Saskatoon	16	0.3	0.0	0.1	171	2.8
Sault Ste. Marie	31	0.3	0.1	0.2	67	7.4
Toronto	30	0.5	0.1	0.2	141	7.3
Vancouver	30	0.3	0.0	0.2	86	12.7
Whitehorse	31	0.3	0.0	0.2	37	1.0
Windsor	29	0.4	0.1	0.2	79	5.8
Winnipeg	31	0.5	0.2	0.3	71	2.2
Yellowknife	30	0.3	0.1	0.2	166	0.9
Network summary	704	0.5	0.0	0.2	104	5.0

evaporated under an infra-red lamp, and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}–Y^{90} source. Gross beta activities for December 1964 samples are given in table 4. Radionuclide analyses are reported quarterly in RHD.

4. Mexican Air Monitoring Program December 1964

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*8–12*).

In 1961 the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance network. This network consists of 17 stations (see figure 5), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRP operate the Station at Mexico City, while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6 x 8-inch glass fiber filter, using high volume samplers. After each 24 hour sampling period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios sobre Contaminación Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of

FIGURE 5. FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

radon and thoron daughter natural radioactivity. Data are not extrapolated to time of collection.

Results

The maximum, minimum, and average fission product beta concentrations in surface air during December 1964 are presented in table 5.

TABLE 5.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, DECEMBER 1964

Station	Number of Samples	Gross beta activity (pc/m³)		
		Maximum	Minimum	Average
Acapulco	9	<0.1	<0.1	<0.1
Ciudad Juárez	15	0.4	<0.1	0.2
Chihuahua	18	0.3	<0.1	0.1
Ensenada	8	0.3	0.1	0.2
Guadalajara	18	1.2	<0.1	0.1
Guaymas	10	0.7	<0.1	0.2
La Paz	20	0.5	<0.1	0.2
Matamoros	4	<0.1	<0.1	<0.1
Mazatlán *				
Mérida	9	0.2	<0.1	0.1
México, D.F.	15	0.1	<0.1	0.1
Nuevo Laredo	10	0.5	<0.1	0.2
San Luis Potosí	14	0.2	<0.1	<0.1
Tampico	16	0.3	<0.1	0.1
Torreón	24	0.5	<0.1	0.1
Tuxtla Gutiérrez *				
Veracruz	21	0.3	<0.1	0.1

* Blank indicates station temporarily shut down.

5. Pan American Air Sampling Program December 1964

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by four countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization and the Public Health Service (PHS) for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The four air sampling stations included in the Program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; and in Santiago, Chile, by the Occupational Health Service.

The Kingston station began operation in March 1964, and the other three were started near the end of 1962.

The December 1964 air monitoring results from the four participating countries are given in table 6.

TABLE 6.—GROSS BETA ACTIVITY IN AIR, DECEMBER 1964

[Concentrations in pc/m³]

Sampling stations	No. of samples	Maximum	Minimum	Average *
Kingston, Jamaica	21	0.19	<0.10	0.12
Caracas, Venezuela	9	<0.10	<0.10	<0.10
Lima, Peru	0	—	—	—
Santiago, Chile	29	0.23	<0.10	0.13

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

6. Gross beta activity in air, North America December 1964

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America. The data from the Radiation Surveillance Network and the Canadian Air Network may be adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*13*). Because of extremely low levels of gross beta activity in air during December 1964, the isogram presentation is omitted.

With the formation of the Mexican Air Monitoring Program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, Pan American Air Sampling Program, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*14*). The new intercalibration factors reflect some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963. The RSN and Pan American data were multiplied by an intercalibration factor of 1.28, and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

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DETECTION OF FALLOUT FROM CHINESE NUCLEAR TEST OF OCTOBER 16, 1964, BY THE NATIONAL AIR SAMPLING NETWORK

B. Branson [1], *E. Tabor* [1], *G. Holzworth* [2], *S. Gold* [1], *J. Hardin* [1], *and B. Kahn* [1]

Beginning October 21, 1964, air filters from the NASN stations shown in figure 1 were analyzed for recently formed fission products resulting from the mainland Chinese atmospheric nuclear test. Samples were taken daily by or for the Division of Air Pollution at Los Angeles, St. Louis, and Washington; Cincinnati samples were collected daily by personnel of Radiological Health Research Activities. Seven additional stations along the northern boundary and west coast of the United States sampled daily between October 21 and 27. On October 28 all NASN stations collected their regular biweekly 24-hour sample for gross beta activity concentration measurement; the results are shown in figure 2.

At each station, suspended particular matter was collected with a high-volume pump on an 8- by 10-inch glass fiber filter over a 24-hour period from approximately 2,000 cubic meters of air. After collection the filters were removed and sent to the Robert A. Taft Sanitary Engineering Center for analysis. Gross beta activity from fallout was measured with an end-window proportional counter 4 or more days after collection so that the contribution of activity from the short-lived radioactive daughters of the naturally occurring radon and thoron would be eliminated. The radioactivity concentration, in picocuries per cubic meter of air (pc/m^3), was determined by:

$$\text{pc/m}^3 = \frac{KC}{FEV}$$

where K = pc/dpm
C = count rate, cpm
F = self-absorption factor
E = counter efficiency, cpm/dpm
V = air volume, m^3.

Any significant increase in gross activity alerted the counting room to obtain a gamma scan of the filter. The gamma radiation was measured with a 4 x 4-inch NaI (Tl) crystal and a 200-channel spectrometer. In many of the samples it was possible to identify 12.8-day Ba^{140}-La^{140}, 3.2-day Te^{132}-I^{132}, 2.8-day Mo^{99}, and 2.4-day Np^{239} based upon rates of decay and characteristic gamma peak energies. The presence of Np^{239} results from the decay of U^{239}, the neutron activation product of U^{238}; the other radionuclides are common fission products.

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[1] Messrs. Branson, Gold, and Hardin are staff members and Dr. Kahn is Chief of Radiological Health Research Activities, Division of Radiological Health, and Dr. Tabor is Chief of the National Air Sampling Laboratory of Engineering and Physical Sciences, Division of Air Pollution; both of these Divisions are agencies of the Public Health Service, U.S. Department of Health, Education and Welfare, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

[2] Mr. Holzworth is the Supervisory Research Meteorologist of the U.S. Weather Bureau Research Station, Cincinnati, Ohio.

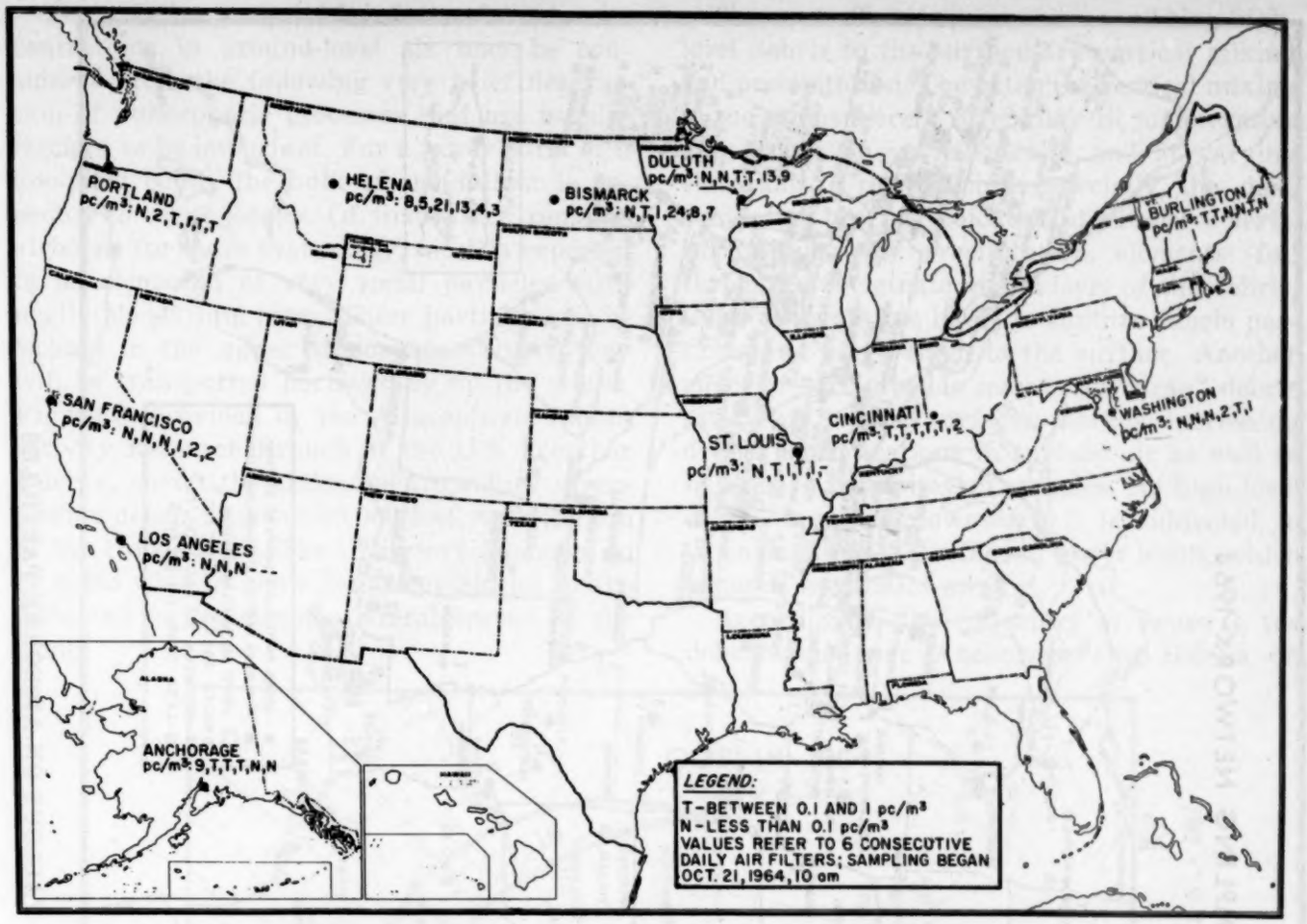

FIGURE 1. RECENTLY FORMED FALLOUT ON AIRBORNE PARTICLES NASN STATIONS AND RHRA CINCINNATI STATION, USING GLASS FIBER FILTERS WITH AIR VOLUME OF APPROXIMATELY 2000 m^3/day.

Figures 1 and 2 show the gross beta concentrations of recently formed radionuclides on airborne particles. To correct for the gross beta activity from older fission products, their average concentration during this time, 0.5 pc/m^3, was subtracted from the total concentration. The concentration of older fission products before October 16 varied between <0.1 and 1.0 pc/m^3, so that the larger values, rounded to the nearest integer, provide a fair indication of relative concentration. Below a concention of 1 pc/m^3 for recently formed radionuclides, the value obtained by this subtraction obviously is quite approximate; the presence of fresh fallout, as shown by gamma spectral analysis, is indicated by "T" for "trace." When recently formed fallout was below 0.1 pc/m^3, corresponding to approximately 0.01 pc/m^3 of Ba^{140} or Te^{132}, it could not be detected, as indicated by "N" in figures 1 and 2.

All of the radionuclide concentrations are given as measured 4 to 12 days after collection. In view of the Way-Wigner $t^{-1.2}$ decay relationship (*1*), where the time between radionuclide formation and counting, t, was 9 to 24 days, the activity on the day of collection would have been appreciably higher. Decay corrections to the day of collection lead to computed values that are as much as twice those listed.

Figures 1 and 2 show that most sampling stations in the United States received at least a trace of the fallout from the Chinese nuclear test. The highest measured gross beta radioactivity concentrations in air were at Bismarck on October 24-25, Helena on October 23-24, and Orlando on October 27-28. The respective values were 24, 21, and 18 pc/m^3 on the day of counting, corresponding to 38, 36, and 28 pc/m^3 on the day of collection according to the $t^{-1.2}$ decay correction.

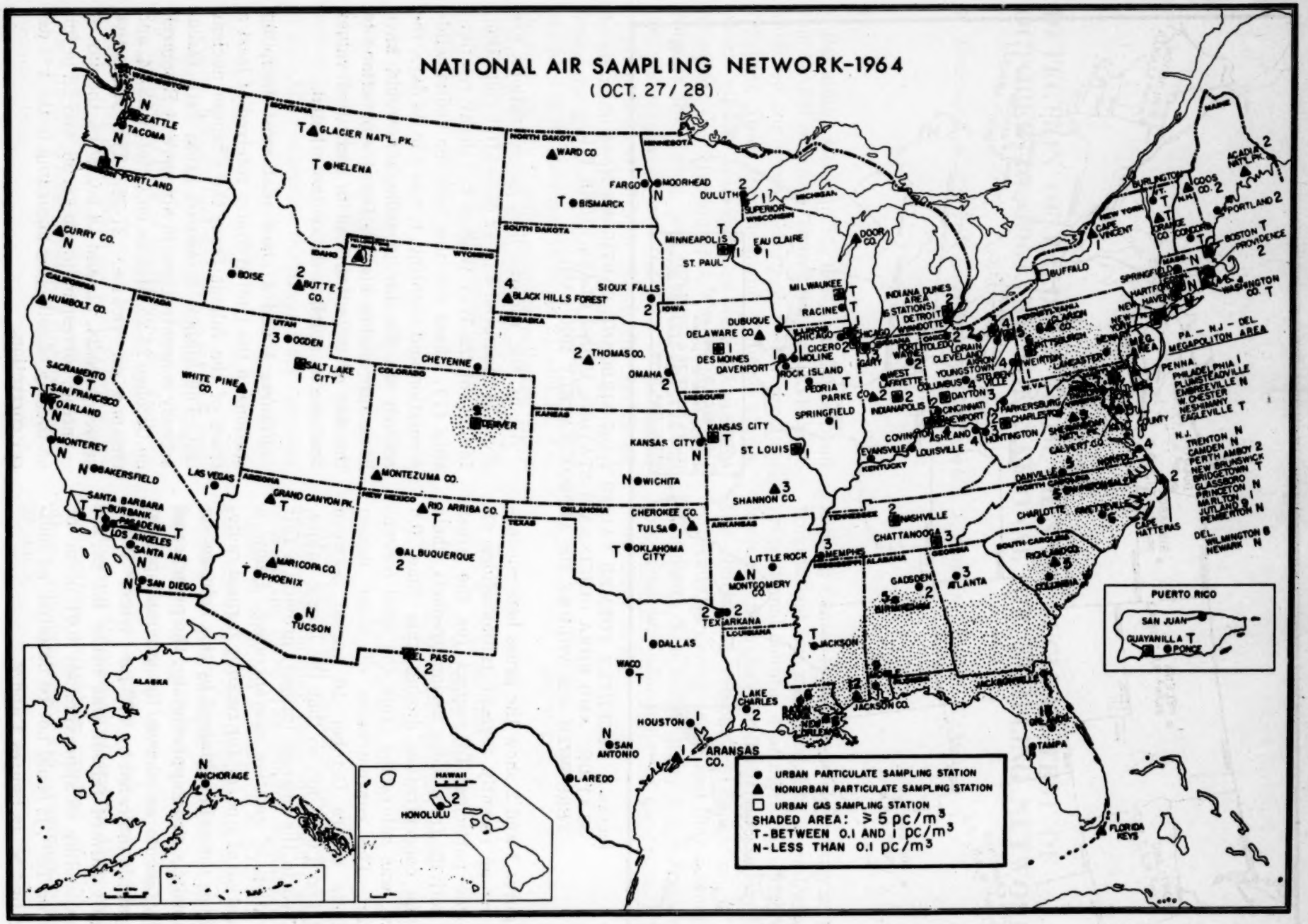

FIGURE 2. RECENTLY FORMED FALLOUT ON AIRBORNE PARTICLES

The relative magnitude of the fallout concentrations in ground-level air may be considered from the following very brief description of atmospheric processes that are usually thought to be important. For a tower burst of a low-yield bomb, the bulk of the fallout is expected to occur locally. Of that which remains airborne for more than a day, most is expected to be composed of very small particles with negligible settling rates. These particles will be located in the upper troposphere where they will be transported horizontally by the winds. Figure 3, provided by the Atmospheric Radioactivity Research Branch of the U.S. Weather Bureau, shows the estimated trajectory of explosion debris at about 30,000 feet, near the top of the troposphere. The trajectory is shown to be quite wide to allow for uncertainties in the data and to depict some lateral spread of the cloud.

The most effective mechanisms to bring high-level debris to the surface are vertical mixing and precipitation. The extent of vertical mixing in the atmosphere is often difficult to determine and occurs on various scales and at varying elevations. Precipitation, especially the deep convective type, is indicative of extensive vertical mixing. If precipitation elements fall through or originate at the level of the debris, these elements are likely to capture debris particles and carry them to the surface. Another effect of precipitation may be to "drag" debris air down to the surface, thereby increasing debris concentrations in surface air as well as in surface precipitation samples. As high-level debris is mixed downward it is subjected to variable horizontal winds at lower levels, which enhance horizontal mixing.

According to the trajectory of figure 3, the debris was over Anchorage and Helena on

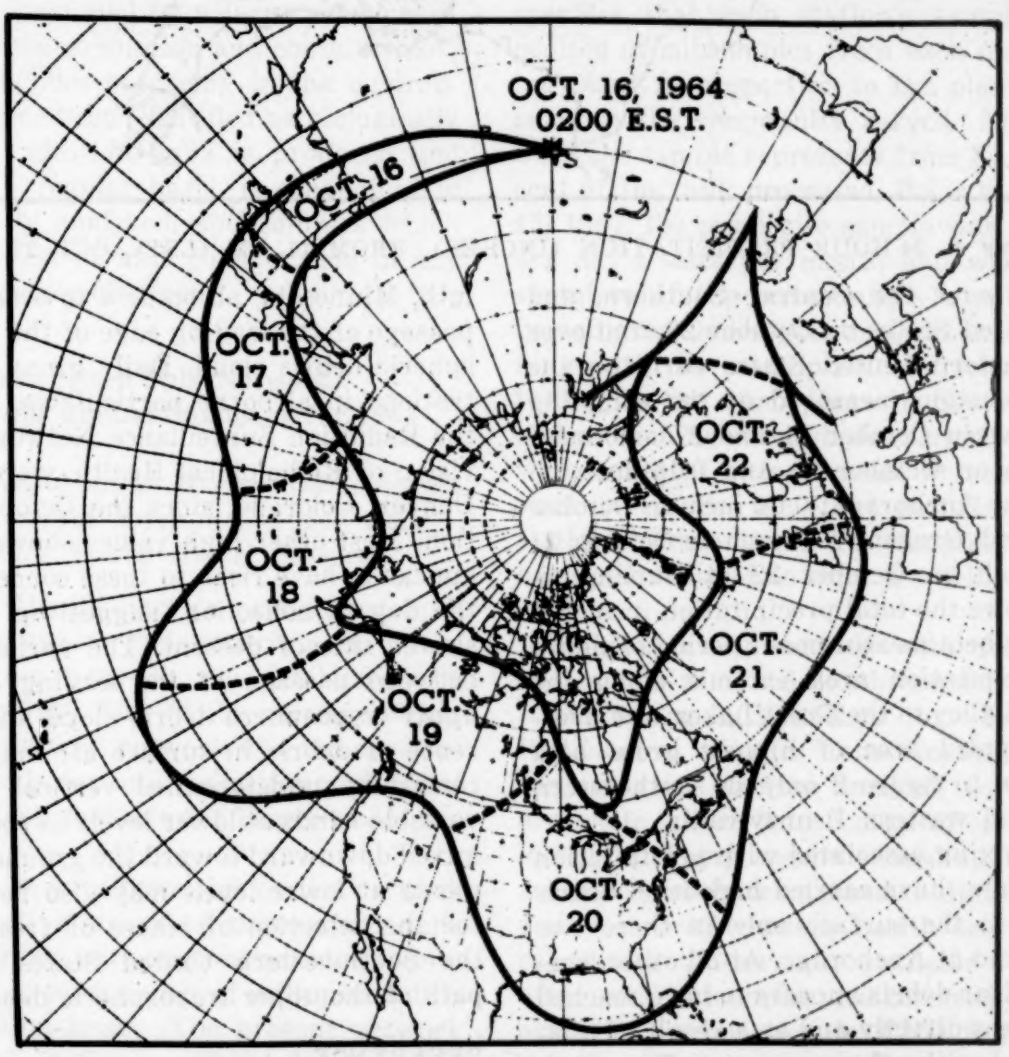

FIGURE 3. APPROXIMATE PATH OF UPPER TROPOSPHERIC DEBRIS FROM THE FIRST CHINESE NUCLEAR DETONATION

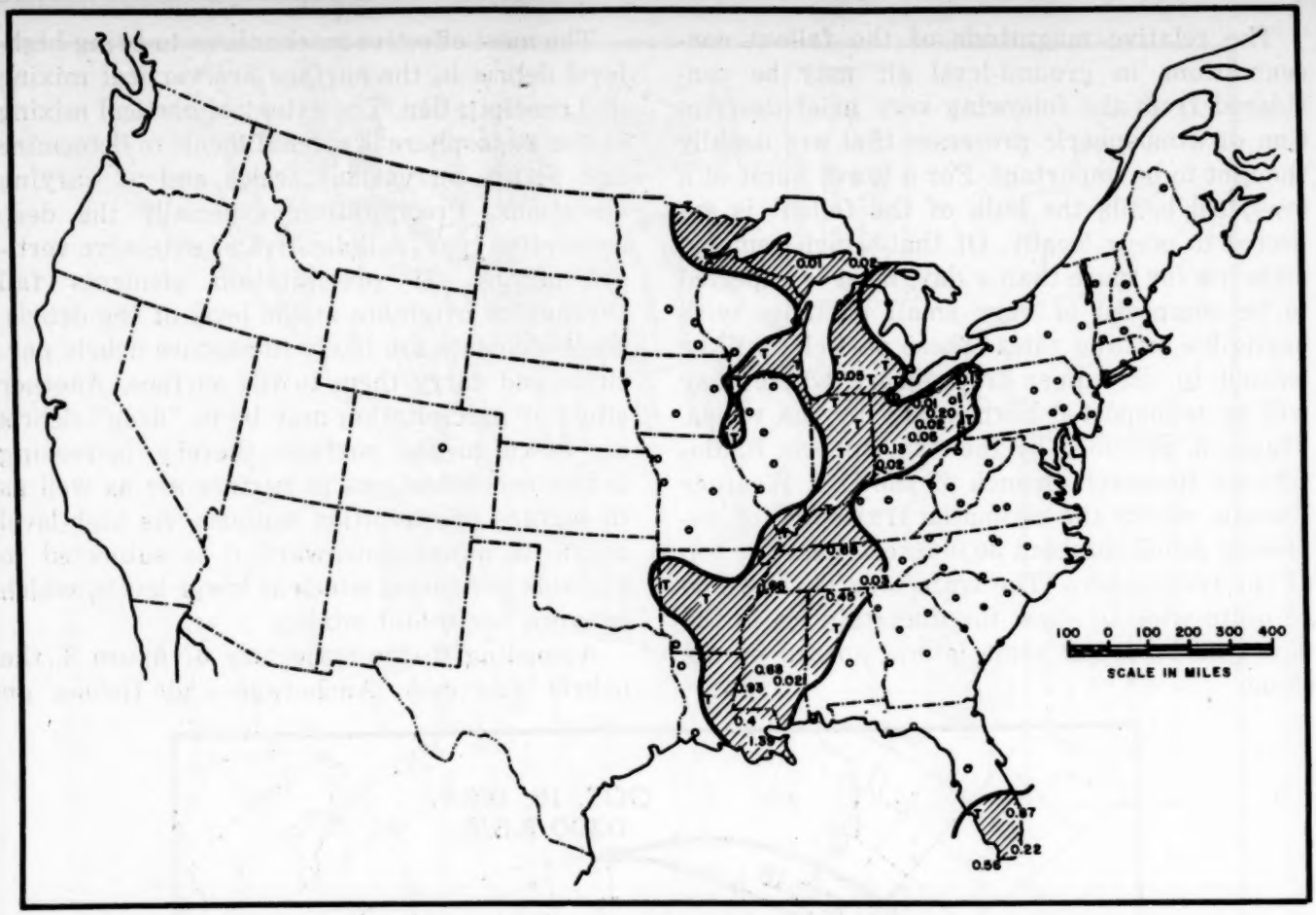

FIGURE 4. 24-HOUR PRECIPITATION (INCHES), FROM 11 AM (LST), OCT. 27, 1964

October 19, over the Central, Southern, and Eastern United States on October 20, and over the Northeastern United States early on the 21st. Precipitation measured at the sampling stations between October 21 and 27 amounted to 0.73 inch on October 21 and 0.16 inch on October 27 at Anchorage; 0.04 inch on October 27 at Portland, Oregon; 0.03 inch on October 21 and 0.01 inch on October 22 at Burlington. Figure 4 shows the total precipitation in inches for the gross beta measurement period of figure 2. The precipitation area extends along the Mississippi Valley to the Great Lakes, and overlaps the stippled area of highest gross beta concentration in figure 2 only in southeastern Louisiana and western Pennsylvania.

Vertical mixing associated with precipitation could, therefore, have carried high-level debris air directly to the surface only in these two small areas and at Anchorage. At all other locations the nuclear debris appears to have reached the surface less directly and as a result of mixing associated with other processes. The maximum radionuclide concentrations at Helena, Montana; Bismarck, North Dakota; and Duluth, Minnesota, all occur 4 to 5 days after the passage of the leading edge of the upper tropospheric debris cloud. Daily gross beta concentrations in airborne particulates, tabulated by the Radiation Surveillance Network of the Division of Radiological Health, were elevated at Denver, Colorado, since the October 24 collection. Most other high values shown in figure 2 appear to have risen to these concentrations on the day of collection, suggesting a somewhat slower rate of descent. The variable time lag between passage of the leading edge of the upper troposphere debris cloud and the occurrence of debris in surface air may have been caused by undetermined vertical mixing and variable winds at lower levels as the debris was mixed downward toward the ground. Air movements at lower levels may also be responsible for the detection of traces of fresh fallout in the Southwestern United States, out of the path of the upper tropospheric debris.

REFERENCE

(*1*) WAY, K. and E. P. WIGNER. The rate of decay of fission products. Phys Rev 73:1318–1330 (June 1, 1948).

Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, December and Annual Summary for 1964

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of the raw milk network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network consists of 63 stations, with at least one in every State, the Canal Zone, and Puerto Rico.

Sampling Procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each station. The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Samples are preserved with formaldehyde and sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NEHRL) for analysis. Gamma analyses for iodine-131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after weekly samples are received by the laboratories; publication in *RHD* follows 3 to 4 months after the monthly samples are composited for analyses.

Analytical Procedures

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectroscopy.[1] After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically for strontium-89 and strontium-90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error [a] (pc/liter)	Estimated concentration (pc/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10
Barium-140	0 to 100	±10	100 or greater	±10
Cesium-137	0 to 100	±10	100 or greater	±10
Strontium-89	0 to 50	± 5	50 or greater	±10
Strontium-90	0 to 20	± 2	20 or greater	±10

[a] Two standard deviations (2σ).

The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium-40 concentrations [2] determined from the gamma spectrum.

Data Presentation

Table 2 presents summaries of the analyses for December (actual reporting period November 29-December 26) and fourth quarter 1964. Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averagd by using one-half the minimum detectable value. The averaging procedure was modified for iodine-131 and barium-140 in October 1963 when nondetectable concentrations of these radionuclides were considered zero. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium-90 and cesium-137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isograms are made according to available information on milksheds.

In tables 3 and 4, the distribution of the network's stations *versus* radionuclide concentrations in milk for the last 6 months are compared.

For special purposes of comparison and reference, the Network maximum, minimum, and average monthly radionuclide concentrations for the early years of operation (March 1960-March 1964) were summarized in tabular form in the July 1964 *RHD* (*2*).

The average monthly strontium-90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3. Each graph shows the strontium-90 concentrations in milk from one city in each of the four U.S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year.

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

[2] The conversion factor is 1.18×10^{-3} g K/pc K^{40}.

TABLE 2.—STABLE ELEMENT AND RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, DECEMBER 1964 AND FOURTH QUARTER 1964

Sampling locations		Calcium (g/liter)		Strontium-89 (pc/liter)		Strontium-90 (pc/liter)		Cesium-137 (pc/liter)		Iodine-131 (pc/liter)		Barium-140 (pc/liter)	
		Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month
Ala:	Montgomery	1.20	1.24	<5	<5	19	20	60	55	0	0	0	0
Alaska:	Palmer	1.22	1.20	<5	<5	19	20	80	80	0	0	0	0
Ariz:	Phoenix	1.19	1.18	<5	<5	4	4	25	30	0	0	0	0
Ark:	Little Rock	1.17	1.18	<5	<5	33	32	60	60	0	10	0	0
Calif:	Sacramento	1.26	1.28	<5	<5	5	4	25	30	0	0	0	0
	San Francisco	1.22	1.24	<5	<5	8	8	30	30	0	0	0	0
C. Z:	Cristobal	1.14	1.16	<5	<5	5	6	50	45	0	0	0	0
Colo:	Denver	1.29	1.38	<5	<5	16	17	65	60	0	0	0	0
Conn:	Hartford	1.13	1.11	<5	<5	14	15	85	90	0	0	0	0
Del:	Wilmington	1.17	1.15	<5	<5	16	17	70	70	0	0	0	0
D. C:	Washington	1.15	1.19	<5	<5	17	16	45	50	0	0	0	0
Fla:	Tampa	1.18	1.20	<5	<5	15	14	210	190	0	0	0	0
Ga:	Atlanta	1.20	1.22	<5	<5	24	24	85	80	0	0	0	0
Hawaii:	Honolulu	1.20	1.18	5	<5	13	9	70	75	0	0	0	0
Idaho:	Idaho Falls	1.23	1.24	<5	<5	19	22	80	100	0	0	0	0
Ill:	Chicago	1.16	1.14	<5	<5	16	17	75	80	0	0	0	0
Ind:	Indianapolis	1.20	1.19	<5	<5	15	15	60	70	0	0	0	0
Iowa:	Des Moines	1.22	1.19	<5	<5	21	21	55	65	0	0	0	0
Kans:	Wichita	1.26	1.26	<5	<5	17	17	40	50	0	0	0	0
Ky:	Louisville	1.18	1.20	<5	<5	23	22	45	50	0	0	0	0
La:	New Orleans	1.23	1.24	10	10	40	40	75	70	0	0	0	0
Maine:	Portland	1.18	1.15	<5	<5	24	24	145	140	0	0	0	0
Md:	Baltimore	1.16	1.19	<5	<5	18	18	50	55	0	0	0	0
Mass:	Boston	1.15	1.14	<5	<5	22	21	125	135	0	0	0	0
Mich:	Detroit	1.17	1.14	<5	<5	15	14	75	75	10	0	0	0
	Grand Rapids	1.20	1.16	<5	<5	19	18	85	85	0	0	0	0
Minn:	Minneapolis	1.24	1.24	5	<5	24	24	80	90	0	0	0	0
Miss:	Jackson	1.23	1.27	<5	5	32	32	60	50	0	0	0	0
Mo:	Kansas City	1.22	1.22	<5	<5	21	20	40	45	0	0	0	0
	St. Louis	1.24	1.25	<5	<5	18	18	45	50	0	0	0	0
Mont:	Helena	1.25	1.23	<5	<5	16	17	85	90	0	0	0	0
Nebr:	Omaha	1.19	1.21	<5	<5	17	15	45	50	0	0	0	0
Nev:	Las Vegas	1.24	1.30	<5	<5	8	7	50	60	0	0	0	0
N. H:	Manchester	1.18	1.16	<5	<5	23	23	155	165	0	0	0	0
N. J:	Trenton	1.12	1.11	<5	<5	15	14	70	80	0	0	0	0
N. Mex:	Albuquerque	1.23	1.22	<5	<5	9	9	45	50	0	0	0	0
N. Y:	Buffalo	1.11	1.10	<5	<5	16	18	90	100	0	0	0	0
	New York	1.15	1.10	<5	<5	19	18	95	105	0	0	0	0
	Syracuse	1.12	1.12	<5	<5	15	15	90	100	0	0	0	0
N. C:	Charlotte	1.21	1.24	<5	<5	33	34	65	65	0	0	0	0
N. Dak:	Minot	1.19	1.16	<5	<5	38	40	110	130	0	0	0	0
Ohio:	Cincinnati	1.19	1.18	<5	<5	17	17	60	65	0	0	0	0
	Cleveland	1.17	1.12	<5	<5	18	18	75	85	0	0	0	0
Okla:	Oklahoma City	1.18	1.24	5	<5	18	19	45	45	0	0	0	0
Ore:	Portland	1.29	1.29	<5	<5	22	22	90	100	0	0	0	0
Pa:	Philadelphia	1.18	1.16	<5	<5	16	16	65	65	0	0	0	0
	Pittsburgh	1.18	1.16	<5	<5	24	25	85	100	0	0	0	0
P. R:	San Juan	1.14	1.16	<5	<5	10	10	50	50	0	0	0	0
R. I:	Providence	1.17	1.15	<5	<5	18	17	95	100	0	0	0	0
S. C:	Charleston	1.17	1.20	<5	5	29	28	90	90	0	0	0	0
S. Dak:	Rapid City	1.03	1.02	<5	<5	27	22	115	130	0	0	0	0
Tenn:	Chattanooga	1.20	1.22	5	5	31	30	65	60	0	0	0	0
	Memphis	1.20	1.24	<5	<5	25	24	45	50	0	0	0	0
Tex:	Austin	1.14	1.14	<5	<5	7	6	25	25	0	0	0	0
	Dallas	1.18	1.20	<5	<5	15	16	35	40	0	0	0	0
Utah:	Salt Lake City	1.34	1.28	<5	<5	18	21	90	110	0	0	0	0
Vt:	Burlington	1.16	1.12	<5	<5	20	19	105	115	10	0	0	0
Va:	Norfolk	1.19	1.20	<5	<5	21	22	60	60	0	0	0	0
Wash:	Seattle	1.24	1.26	<5	<5	20	20	95	90	0	0	0	0
	Spokane	1.30	1.30	<5	<5	22	23	95	110	0	0	0	0
W. Va:	Charleston	1.16	1.20	<5	<5	17	16	40	40	0	0	0	0
Wis:	Milwaukee	1.22	1.18	<5	<5	14	14	85	90	0	0	0	0
Wyo:	Laramie	1.22	1.22	<5	<5	15	15	70	75	0	0	0	0
Network average		1.19	1.20	<5	<5	18.8	18.7	73	77	0	0	0	0

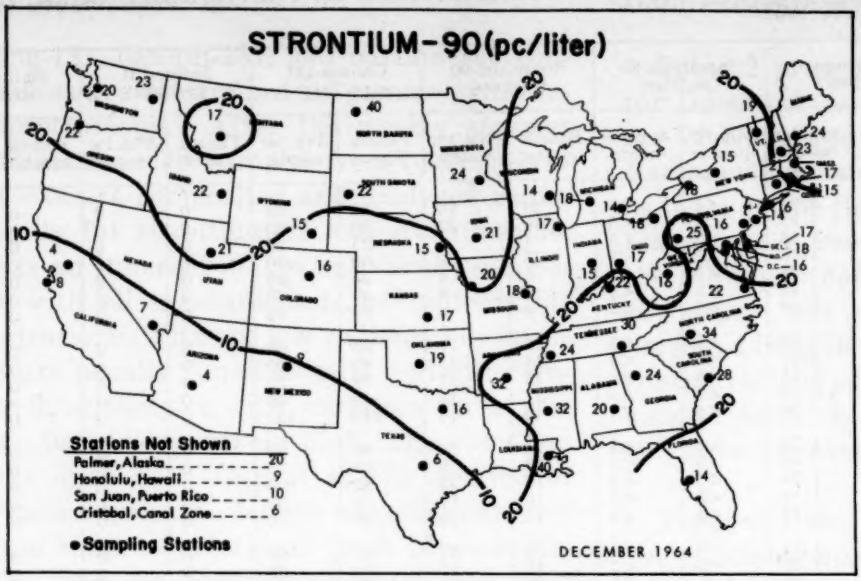

FIGURE 1. STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

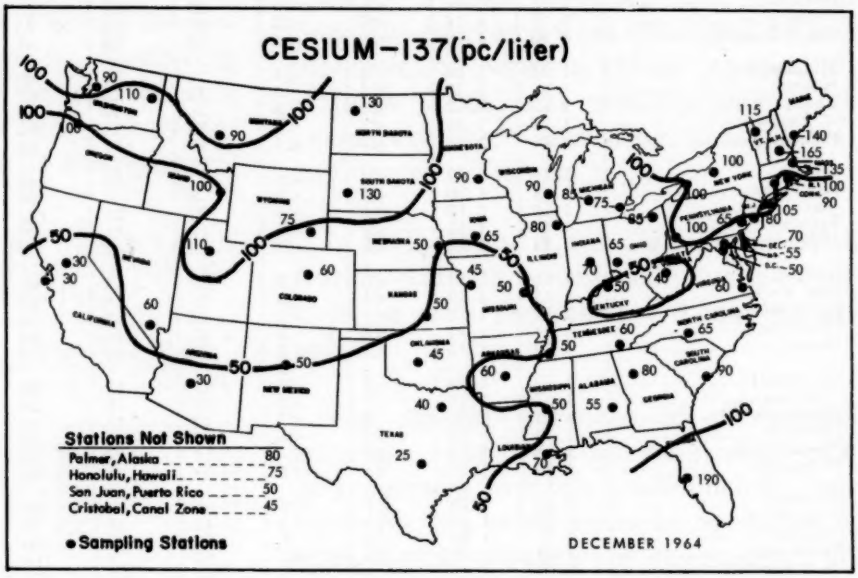

FIGURE 2. CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK

TABLE 3.—RANGES OF STATION MONTHLY AVERAGES FOR STRONTIUM-90, JULY-DECEMBER 1964 AND DECEMBER 1963

Strontium-90 range	Number of stations in range						
	1964						1963
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Dec.
Under 10 pc/l	6	7	8	6	6	8	4
10–19 pc/l	6	23	27	37	31	29	11
20–29 pc/l	29	23	20	13	19	20	33
30–39 pc/l	14	6	6	7	6	4	11
40–49 pc/l	4	4	2	0	1	2	3
50–59 pc/l	1	0	0	0	0	0	0
60–69 pc/l	2	0	0	0	0	0	1
70–79 pc/l	0	0	0	0	0	0	0

TABLE 4.—RANGES OF STATION MONTHLY AVERAGES FOR CESIUM-137, JULY-DECEMBER 1964 AND DECEMBER 1963

Cesium-137 range	Number of stations in range						
	1964						1963
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Dec.
Under 50 pc/l	4	6	14	16	15	9	3
50–99 pc/l	24	30	33	40	41	38	16
100–149 pc/l	21	19	13	6	4	14	23
150–199 pc/l	8	6	2	0	2	2	14
200–249 pc/l	3	1	1	1	1	0	5
250–349 pc/l	2	1	0	0	0	0	2

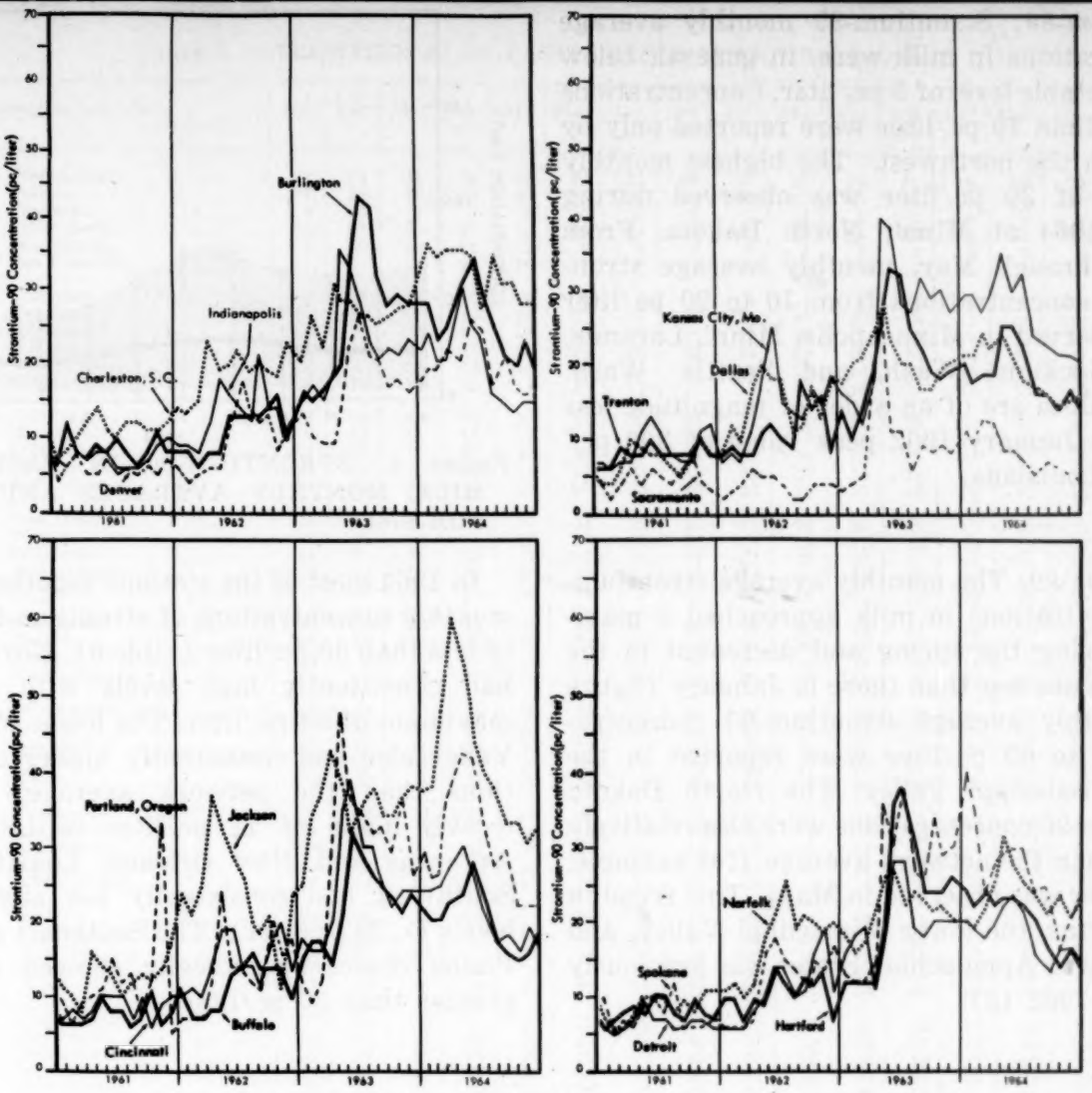

FIGURE 3. STRONTIUM-90 IN PASTEURIZED MILK, 1961–DECEMBER 1964

Summary of 1964 Network Results

With the completion of December milk analyses, it is appropriate to present an annual summary of the concentrations of stable calcium and potassium, strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 for 1964.

Stable calcium and potassium: The monthly average calcium concentrations varied around an annual average of 1.18 grams per liter, with a range of 1.16 to 1.21 grams per liter. Potassium monthly average concentrations exhibited little variation around the annual average of 1.5 grams per liter. Individual monthly averages and ranges are given in table 5.

TABLE 5.—STABLE CALCIUM AND POTASSIUM IN PASTEURIZED MILK–1964

Month	Calcium (g/liter)		Potassium (g/liter)	
	Average	Range	Average	Range
January	1.21	1.15–1.30	1.6	1.4–1.7
February	1.20	1.11–1.26	1.6	1.5–1.7
March	1.19	1.11–1.28	1.5	1.4–1.8
April	1.18	1.01–1.30	1.5	1.3–1.6
May	1.18	1.09–1.28	1.5	1.4–1.6
June	1.17	1.12–1.27	1.5	1.4–1.6
July	1.17	1.10–1.28	1.5	1.4–1.6
August	1.17	1.08–1.31	1.5	1.2–1.7
September	1.16	1.03–1.30	1.5	1.2–1.6
October	1.18	0.98–1.41	1.5	1.3–1.6
November	1.21	1.10–1.34	1.5	1.3–1.6
December	1.20	1.02–1.38	1.5	1.4–1.8
Annual	1.18	0.98–1.41	1.5	1.2–1.8

Strontium-89: Strontium-89 monthly average concentrations in milk were, in general, below the detectable level of 5 pc/liter. Concentrations greater than 10 pc/liter were reported only by States in the northwest. The highest monthly average of 30 pc/liter was observed during March 1964 at Minot, North Dakota. From March through May, monthly average strontium-89 concentrations from 10 to 20 pc/liter were observed in Minneapolis, Minn., Laramie, Wyo., Spokane, Wash, and Seattle, Wash. These values are of an order of magnitude less than the January 1962 peak value of 300 pc/liter in Louisiana.

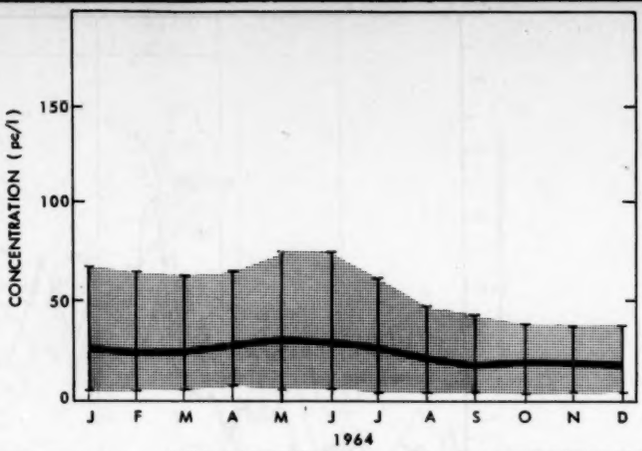

FIGURE 4. STRONTIUM-90 IN PASTEURIZED MILK, MONTHLY AVERAGES AND RANGES FOR 1964

Strontium-90: The monthly average strontium-90 concentrations in milk approached a maximum during the spring and decreased in the fall to values less than those in January (figure 4). Monthly average strontium-90 concentrations up to 69 pc/liter were reported in the lower Mississippi Valley. The North Dakota strontium-90 concentrations were also relatively higher than the network average (for example, 77 pc/liter was observed in May). This trend in the Dakotas, the lower Mississippi Valley, and the southern Appalachian States was previously noted in 1962 (*3*).

In 1964 most of the stations reported average *monthly* concentrations of strontium-90 in milk of less than 30 pc/liter (table 6). North Dakota had consistently high levels with a *weekly* maximum of 84 pc/liter. The lower Mississippi Valley also had consistently higher concentrations than the network average, including *weekly* highs of 71 pc/liter in Little Rock, Arkansas and New Orleans, Louisiana. The Southwest had consistently low strontium-90 levels (<20 pc/liter). The Southeast and Great Plains States sporadically showed values of greater than 30 pc/liter.

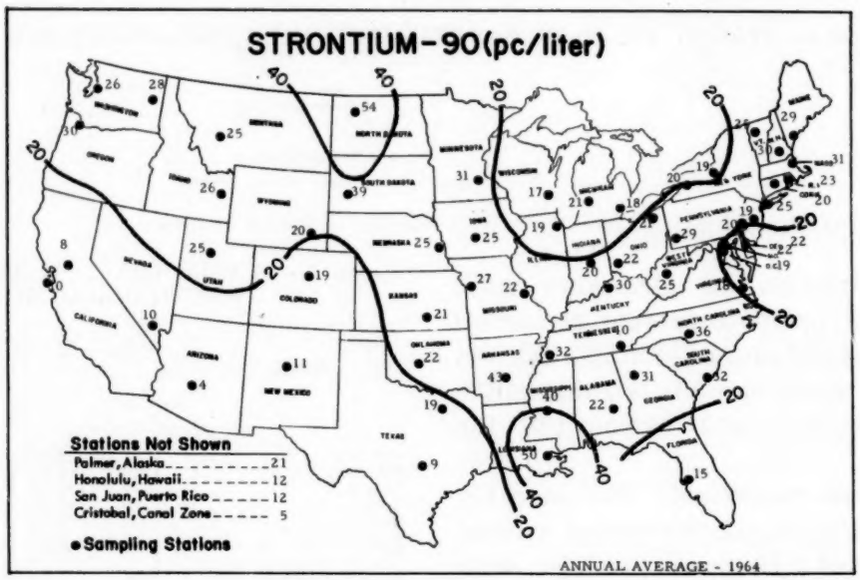

FIGURE 5. STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

TABLE 6. STRONTIUM-90 IN PASTEURIZED MILK, 1964 (pc/liter)

Sampling location		Jan	Feb	Mar	1st qtr	Apr	May	Jun	2nd qtr	Jul	Aug	Sept	3rd qtr	Oct	Nov	Dec	4th qtr	Annual
Ala:	Montgomery	22	24	25	24	26	30	23	26	21	22	19	21	18	20	20	19	22
Alaska:	Palmer	27	23	18	23	20	28	28	25	20	13	16	16	19	19	20	19	21
Ariz:	Phoenix	4	5	4	4	8	5	5	6	3	4	3	3	5	4	4	4	4
Ark:	Little Rock	39	41	50	43	56	69	49	58	40	39	34	38	34	33	32	33	43
Calif:	Sacramento	11	9	12	11	12	8	8	9	7	5	7	6	6	6	4	5	8
	San Francisco	11	13	14	13	16	11	8	12	8	9	4	7	11	4	8	8	10
Canal Zone:	Cristobal	6	6	6	6	6	6	6	6	4	4	6	5	5	5	6	5	5
Colo:	Denver	18	19	19	19	21	20	26	22	24	17	20	20	17	16	16	16	19
Conn:	Hartford	24	22	24	23	22	23	23	23	22	20	16	19	14	14	15	14	20
Del:	Wilmington	22	19	22	21	28	34	28	30	23	19	18	20	14	16	17	16	22
D. C:	Washington	18	17	18	18	21	25	24	23	22	18	16	19	18	17	16	17	19
Fla:	Tampa	14	16	14	15	17	15	14	15	17	15	18	17	16	14	14	15	15
Ga:	Atlanta	30	38	36	35	37	41	30	36	29	29	26	28	24	25	24	24	31
Hawaii:	Honolulu	9	12	11	11	12	10	11	11	10	15	8	11	15	15	9	13	12
Idaho:	Idaho Falls	31	39	10	27	40	30	33	34	30	26	18	25	14	21	22	19	26
Ill:	Chicago	21	21	20	21	18	17	23	19	22	20	14	19	15	16	17	16	19
Ind:	Indianapolis	22	24	20	22	20	30	25	25	23	16	15	18	14	15	15	15	20
Iowa:	Des Moines	27	27	26	27	27	34	28	30	27	20	20	22	19	23	21	21	25
Kans:	Wichita	22	24	24	23	18	28	30	25	21	16	17	18	16	19	17	17	21
Ky:	Louisville	31	31	34	32	37	37	36	37	31	27	23	27	22	24	22	23	30
La:	New Orleans	48	49	64	54	66	59	53	59	52	49	43	48	39	40	40	40	50
Maine:	Portland	32	32	30	31	30	34	35	33	36	26	25	29	22	26	24	24	29
Md:	Baltimore	19	20	22	20	22	30	31	28	26	20	18	21	18	19	18	18	22
Mass:	Boston	35	34	28	32	32	39	43	38	41	30	22	31	21	23	21	22	31
Mich:	Detroit	20	19	18	19	19	22	23	21	21	15	13	16	16	16	15	14	18
	Grand Rapids	23	23	19	22	19	24	26	23	23	18	15	19	18	20	18	19	21
Minn:	Minneapolis	38	38	30	35	30	39	42	37	34	26	22	27	24	23	24	24	31
Miss:	Jackson	37	38	48	41	60	54	44	53	40	38	33	37	33	30	32	32	40
Mo:	Kansas City	29	29	27	28	30	35	30	32	32	24	22	26	21	21	20	21	27
	St. Louis	22	23	24	23	26	30	28	28	29	17	16	21	17	18	18	18	22
Mont:	Helena	28	33	31	31	29	24	32	32	27	19	15	20	15	15	17	16	25
Nebr:	Omaha	23	26	26	25	28	32	31	30	30	22	21	24	19	18	15	17	25
Nev:	Las Vegas	19	14	13	15	6	13	10	10	8	7	4	6	7	10	7	8	10
N. H:	Manchester	35	34	28	32	30	34	36	33	36	28	26	30	23	22	23	23	30
N. J:	Trenton	20	17	18	18	18	25	25	23	23	16	16	18	14	17	14	15	19
N. Mex:	Albuquerque	11	14	11	12	17	12	14	14	12	7	8	9	9	9	9	9	11
N. Y:	Buffalo	21	20	20	20	22	23	28	24	22	17	15	18	14	16	18	16	20
	New York	28	26	22	25	25	28	36	30	32	23	19	25	18	22	18	19	25
	Syracuse	23	22	20	22	21	24	23	23	NS	15	15	15	15	16	15	15	19
N. C:	Charlotte	30	28	36	31	37	46	47	43	39	39	36	38	34	30	34	33	36
N. Dak:	Minot	68	67	39	58	62	77	76	72	63	44	40	49	39	35	40	38	54
Ohio:	Cincinnatti	24	24	25	24	27	30	26	28	21	17	18	19	16	19	17	17	22
	Cleveland	22	20	23	22	19	24	31	25	23	18	16	19	17	18	18	18	21
Okla:	Oklahoma City	22	27	26	25	27	29	26	27	20	18	18	19	17	18	19	18	22
Ore:	Portland	29	26	26	27	36	43	42	40	33	28	30	30	22	23	22	22	30
Pa:	Philadelphia	20	19	20	20	22	28	26	25	21	17	16	18	15	16	16	16	20
	Pittsburg	30	27	28	28	28	34	40	34	35	29	24	29	21	25	25	24	29
P. R:	San Juan	11	12	13	12	16	14	14	15	14	10	12	12	11	10	10	10	12
R. I:	Providence	26	24	25	25	24	27	30	27	25	21	22	23	19	18	17	18	23
S. C:	Charleston	33	36	34	34	35	35	34	35	27	34	31	31	31	28	28	29	32
S. Dak:	Rapid City	40	45	30	38	35	52	58	48	62	40	27	43	28	32	22	27	39
Tenn:	Chattanooga	35	35	44	38	54	52	46	51	42	40	36	39	33	31	30	31	40
	Memphis	28	32	36	32	42	43	40	42	32	31	22	28	27	23	24	25	32
Tex:	Austin	8	11	11	10	9	10	10	10	8	8	6	7	7	8	6	7	9
	Dallas	21	21	24	22	22	24	21	22	18	17	16	17	14	15	16	15	19
Utah:	Salt Lake City	28	28	26	27	32	29	29	30	28	23	24	25	18	14	21	18	25
Vt:	Burlington	28	28	23	26	25	30	34	30	29	25	20	25	19	23	19	20	25
Va:	Norfolk	20	19	22	20	24	31	28	28	25	24	20	23	23	19	22	21	18
Wash:	Seattle	20	20	24	21	24	44	40	36	35	28	22	28	16	24	20	20	26
	Spokane	40	35	24	33	27	29	30	29	30	24	24	26	23	21	23	22	28
W. Va:	Charleston	25	26	28	26	28	40	34	34	26	24	21	24	19	17	16	17	25
Wis:	Milwaukee	21	19	18	19	21	20	21	21	17	14	12	14	14	15	14	14	17
Wyo:	Laramie	19	24	19	21	22	25	29	25	28	18	14	20	14	15	15	15	20
Network average		24.9	25.3	24.3	24.8	26.8	30.3	29.5	28.9	26.3	21.6	19.3	22.3	18.7	19.1	18.7	18.8	23.7
Maximum		68	67	64	58	66	77	76	72	63	49	43	49	39	40	40	40	54
Minimum		4	5	4	4	6	5	5	6	3	4	3	3	5	4	4	4	4

Iodine-131: From January through October 1964 the monthly average iodine-131 concentrations in milk were below detectable limits (10 pc/liter) throughout the country. Following the Mainland China nuclear test of October 16, 1964 an increase of iodine-131 in milk was observed at 29 stations from October 26 to November 23, 1964. The increase was of such a limited nature that only 12 stations exhibited monthly averages greater than the detection

limit. The highest individual value was 60 pc/liter as observed in Albuquerque, New Mexico on October 26, 1964. Iodine-131 was not observed at sampling stations in the South and Southeast. For those stations where increases were observed, the individual sample results are shown in table 7. Since November 23, 1964, levels of iodine-131 in milk have remained below the detectable limit of 10 pc/liter.

TABLE 7.—OCCURRENCE OF IODINE-131 IN PASTURIZED MILK, 1964

[Concentration in pc/liter]

		October						November																						
		26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Colo:	Denver	a	---	20	---	---	---	---	---	---	---	a	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Del:	Wilmington	---	---	---	---	---	---	---	---	---	---	20	---	---	---	---	---	---	---	a	---	---	---	---	---	---	---	---	---	---	---
Idaho:	Idaho Falls	20	---	---	---	---	---	---	---	---	a	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Ill:	Chicago	---	---	---	---	---	---	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Ind:	Indianapolis	---	---	---	---	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---	---	a	---	---	---	---	---	---	---
Maine:	Portland	---	10	---	---	---	---	---	---	20	---	---	---	---	---	---	a	---	---	---	---	---	---	10	---	---	---	---	---	---	---
Mass:	Boston	---	---	---	---	---	---	---	---	10	---	---	---	---	---	---	a	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Mich:	Detroit	---	50	---	---	---	---	---	30	---	---	---	---	---	---	---	10	---	---	---	---	---	a	---	---	---	---	---	---	---	---
	Grand Rapids	20	---	---	---	---	---	---	20	---	---	---	---	---	---	30	---	---	---	---	---	---	a	---	---	---	---	---	---	---	---
Minn:	Minneapolis	---	20	---	---	---	---	---	---	a	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Miss:	Jackson	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	a	---	---	---	---	---	---	20	---
Mont:	Helena	a	---	30	---	---	---	---	---	---	a	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Nev:	Las Vegas	---	---	---	30	---	---	---	---	---	---	NS	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
N. H:	Manchester	---	---	---	---	---	---	---	---	---	20	---	---	---	---	---	a	---	---	---	---	---	---	10	---	---	---	---	---	---	---
N. J:	Trenton	---	10	---	---	---	---	---	---	30	---	---	---	---	---	---	a	---	---	---	---	---	---	10	---	---	---	---	---	---	---
N. Mex:	Alburquerque	60	---	---	---	---	---	---	---	a	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
N. Y:	Buffalo	---	---	---	20	20	---	---	---	---	---	---	10	---	---	---	---	---	---	a	---	---	---	---	---	---	---	---	---	---	---
	New York	---	---	---	---	---	---	---	30	---	---	---	---	---	---	10	---	---	---	---	---	---	a	---	---	---	---	---	---	---	---
	Syracuse	---	---	20	---	---	---	---	---	---	10	---	---	---	---	---	a	---	---	---	---	---	---	---	---	---	---	---	---	---	---
N. Dak:	Minot	---	---	---	---	---	---	---	20	---	---	---	---	---	---	a	---	---	a	---	---	---	---	---	---	---	---	---	---	---	a
Ohio:	Cincinnati	---	---	---	---	---	---	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---	10	---	---	---	---	---	---
	Cleveland	---	---	---	---	20	---	---	---	---	---	---	a	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Okla:	Oklahoma City	---	---	---	---	---	---	---	---	a	---	---	---	---	---	a	---	---	---	---	---	---	---	20	---	---	---	---	---	a	---
Pa:	Philadelphia	---	---	---	---	10	---	---	---	---	---	---	a	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Pittsburgh	10	---	---	---	---	---	---	20	---	---	---	---	---	---	a	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---
R. I:	Providence	---	---	---	---	20	---	---	---	---	---	---	a	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Texas:	Austin	---	---	---	---	---	---	---	---	---	---	---	a	---	---	---	---	---	---	10	---	---	---	---	---	---	a	---	---	---	---
Vt:	Burlington	---	40	---	---	---	---	---	---	30	---	---	---	---	---	---	a	---	---	---	---	---	---	10	---	---	---	---	---	---	---
Va:	Norfolk	---	---	---	---	---	---	---	---	a	---	---	---	---	---	---	---	---	---	20	---	---	---	---	---	---	a	---	---	---	---
Wis:	Milwaukee	---	20	---	---	---	---	---	---	20	---	---	---	---	---	---	a	---	---	---	---	---	---	30	---	---	---	---	---	---	a

a Less than detectable.
NS—No sample collected.

Cesium-137: The network monthly average cesium-137 concentrations were observed to decrease as the year passed (table 8). The monthly average values and ranges are shown in figure 6. The general trend indicates a decrease in concentration progressing from north to south. Variation on this trend is observed in the southeast where Florida consistently exhibits higher values than its neighbors. This suggests the presence of a dairy food supply indigenous to that area as the source of cesium-137. Geographical variation in average annual cesium-137 concentrations is observed in figure 7.

Most of the stations exhibited annual average concentrations of cesium-137 in milk of less than 150 pc/liter except for the northwest, northeast, and Florida. In general, levels were observed to decrease steadily throughout the year particularly in 1963. This is seen when

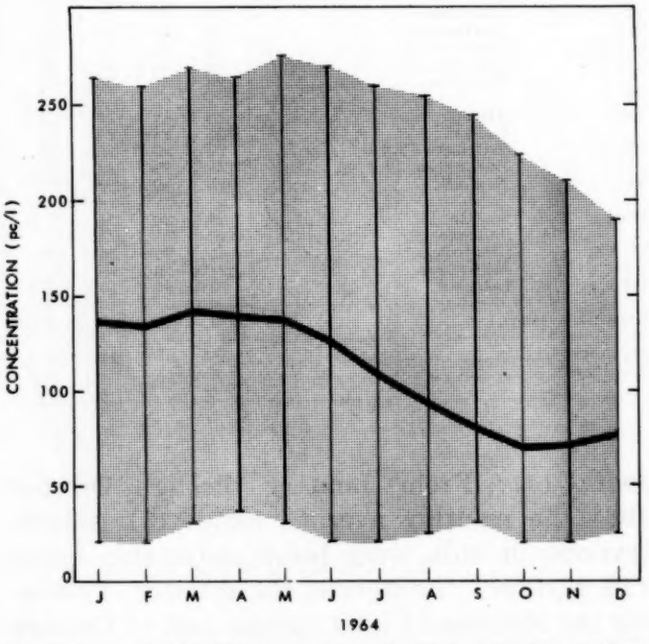

FIGURE 6. CESIUM-137 IN PASTEURIZED MILK, MONTHLY AVERAGES AND RANGES, 1964

TABLE 8.—CESIUM-137 IN PASTEURIZED MILK—1964, (pc/liter)

Sampling location		Jan	Feb	Mar	1st qtr	Apr	May	Jun	2nd qtr	Jul	Aug	Sept	3rd qtr	Oct	Nov	Dec	4th qtr	Annual
Ala:	Montgomery	95	105	95	100	95	100	80	90	70	70	60	65	60	60	55	60	79
Alaska:	Palmer	170	165	140	160	155	155	140	150	110	100	100	105	85	80	80	80	124
Ariz:	Phoenix	20	20	30	25	35	30	20	30	20	25	30	25	20	20	30	25	25
Ark:	Little Rock	150	165	175	165	170	190	120	160	90	80	65	80	65	60	60	60	117
Calif:	Sacramento	60	60	70	65	60	40	55	50	35	25	30	30	20	30	30	25	42
	San Francisco	80	75	70	75	65	50	50	55	40	30	30	35	20	35	30	30	48
Canal Zone:	Cristobal	50	50	50	50	55	55	50	55	50	50	50	50	55	50	45	50	51
Colo:	Denver	80	95	100	90	95	80	100	90	120	100	85	100	75	60	60	65	88
Conn:	Hartford	180	180	190	185	175	155	155	160	130	115	90	110	75	90	90	85	135
Del:	Wilmington	145	150	160	150	155	155	130	145	110	85	65	85	65	70	70	70	113
D. C:	Washington	105	105	110	105	110	100	85	100	80	60	55	65	50	40	50	45	79
Fla:	Tampa	185	190	225	200	240	275	270	260	260	255	245	255	225	210	190	210	231
Ga:	Atlanta	145	160	180	160	180	190	130	165	120	105	90	105	90	90	80	85	130
Hawaii:	Honolulu	80	75	85	80	80	85	90	85	70	75	70	70	70	70	75	70	77
Idaho:	Idaho Falls	200	240	215	220	230	195	195	205	140	105	85	110	60	85	100	80	154
Ill:	Chicago	145	145	150	145	145	130	115	130	100	85	70	85	70	70	80	75	109
Ind:	Indianapolis	120	115	130	120	120	105	110	110	90	65	55	70	55	60	70	60	91
Iowa:	Des Moines	110	105	110	110	110	100	90	100	85	65	65	70	45	50	65	55	83
Kans:	Wichita	75	80	85	80	80	80	75	80	60	50	40	50	45	30	50	40	63
Ky:	Louisville	125	125	130	125	125	90	85	100	65	50	40	50	45	45	50	45	81
La:	New Orleans	155	155	190	165	205	195	140	180	125	115	100	115	90	70	70	75	135
Maine:	Portland	230	215	215	220	205	225	200	210	190	180	150	175	135	155	140	145	187
Md:	Baltimore	110	115	125	115	135	130	105	125	90	60	55	70	50	50	55	50	90
Mass:	Boston	265	255	270	265	255	240	240	245	210	195	140	180	105	130	135	125	203
Mich:	Detroit	140	130	135	135	130	130	105	120	110	90	70	90	70	75	75	75	105
	Grand Rapids	145	140	150	145	140	140	120	135	115	100	85	100	85	85	90	85	116
Minn:	Minneapolis	180	190	195	190	160	165	155	160	140	110	90	115	70	75	90	80	135
Miss:	Jackson	120	125	135	125	140	130	100	125	90	90	80	85	65	60	50	60	99
Mo:	Kansas City	105	100	100	100	110	95	90	100	65	50	50	55	35	40	45	40	73
	St. Louis	105	95	105	100	100	90	100	95	70	55	40	55	45	40	50	45	74
Mont:	Helena	235	230	235	235	225	205	155	195	130	100	110	115	85	85	90	85	157
Nebr:	Omaha	100	105	110	105	120	105	85	105	80	75	60	70	45	40	50	45	87
Nev:	Las Vegas	95	85	100	95	90	85	95	90	55	50	45	50	35	55	60	50	70
N. H:	Manchester	265	260	255	260	265	250	235	250	250	200	160	205	140	165	165	155	217
N. J:	Trenton	140	135	150	140	140	140	125	135	105	90	65	85	65	70	80	70	106
N. Mex:	Albuquerque	60	55	60	60	90	55	60	70	50	45	35	45	35	45	50	45	53
N. Y:	Buffalo	165	175	175	170	170	155	150	160	130	105	85	105	80	90	100	90	131
	New York	190	185	195	190	195	175	170	180	150	120	90	120	85	95	105	95	146
	Syracuse	165	165	180	170	165	165	145	160	NS	85	80	80	80	90	100	90	129
N. C:	Charlotte	110	115	120	115	125	155	135	140	110	105	80	100	70	65	65	65	105
N. Dak:	Minot	165	165	155	160	165	175	180	175	185	125	120	145	100	100	130	110	147
Ohio:	Cincinnati	130	125	120	125	120	95	100	105	70	60	45	60	50	60	65	60	86
	Cleveland	130	125	145	135	140	125	140	135	115	80	70	90	65	70	85	75	107
Okla:	Oklahoma City	85	90	90	90	80	75	75	75	60	50	45	50	45	45	45	45	65
Ore:	Portland	170	145	150	155	185	160	220	190	205	175	120	165	85	85	100	90	149
Pa:	Philadelphia	140	140	150	145	150	150	120	140	105	75	65	80	70	60	65	65	110
	Pittsburgh	160	170	175	170	180	175	175	175	160	115	90	120	80	80	100	85	138
P. R:	San Juan	55	70	85	70	100	90	75	90	80	70	65	70	55	50	50	50	70
R. I:	Providence	180	190	185	185	180	175	180	180	165	140	115	140	95	95	100	95	150
S. C:	Charleston	120	150	140	135	140	180	120	145	100	120	110	110	95	90	90	90	122
S. Dak:	Rapid City	180	170	175	175	145	155	170	155	165	105	110	125	100	110	130	115	142
Tenn:	Chattanooga	140	145	155	145	165	145	125	145	95	95	75	90	65	65	60	65	111
	Memphis	90	80	95	90	85	100	70	85	60	55	45	55	40	40	50	45	68
Tex:	Austin	40	55	45	45	40	50	50	45	25	30	45	35	20	25	25	25	38
	Dallas	80	90	85	85	70	70	65	70	50	45	40	45	30	30	40	35	58
Utah:	Salt Lake City	200	210	235	215	225	185	170	195	180	175	140	165	90	65	110	90	165
Vt:	Burlington	220	205	210	210	210	195	170	190	150	155	120	140	90	110	115	105	162
Va:	Norfolk	100	105	110	105	105	125	105	110	90	70	70	75	65	55	60	60	88
Wash:	Seattle	120	115	125	120	140	170	265	190	220	170	125	170	105	90	90	95	144
	Spokane	155	145	140	145	165	155	150	155	140	130	115	130	85	95	110	95	132
W. Va:	Charleston	105	110	110	110	105	95	80	95	60	55	35	50	40	40	40	40	73
Wis:	Milwaukee	160	155	160	160	160	145	135	145	110	90	80	95	80	80	90	85	120
Wyo:	Laramie	105	105	130	115	115	110	130	120	130	105	80	105	60	75	75	70	101
Network average		134	135	141	136	140	135	126	133	110	94	80	94	69	72	77	73	109
Maximum		265	260	270	265	265	275	270	260	260	255	245	255	225	210	190	210	231
Minimum		20	20	30	25	35	30	20	30	20	25	30	25	20	20	25	25	25

comparing December 1963 and December 1964 mean concentrations, table 4.

At no time during 1964 did levels of strontium-89, strontium-90, iodine-131, or cesium-137 concentrations in pasteurized milk reach levels such that remedial actions are suggested based upon health implications.

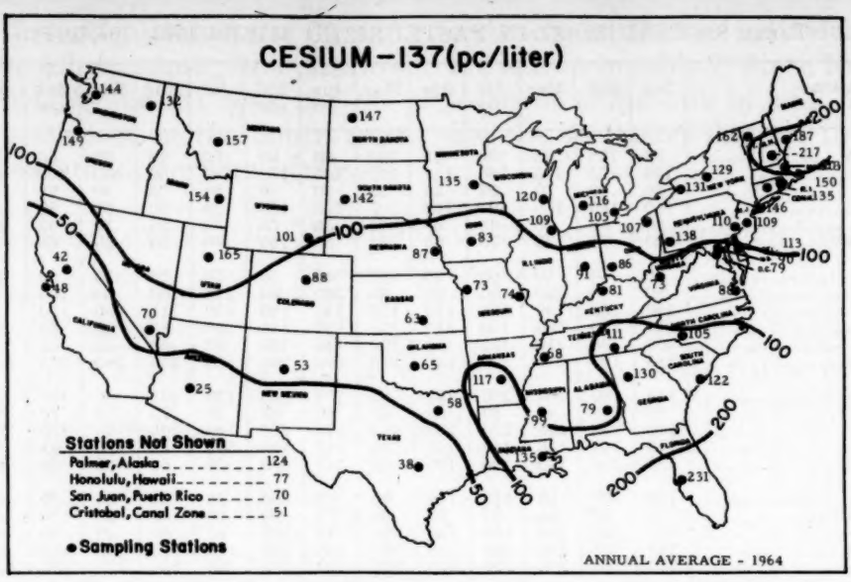

FIGURE 7. CESIUM–137 CONCENTRATIONS IN PASTEURIZED MILK

2. Colorado Milk Network, October–December 1964 and Summary for 1962–1964

Occupational and Radiological Health Division, Colorado State Department of Public Health

The Radiological Health Division of the Colorado State Department of Public Health initiated radiological analysis of milk in January 1962. Initially the Denver City and County Health Department collected a weekly composite milk sample from the major producers in the Denver area for the State, as it had for the Public Health Service since March 1960.

In August 1962, the State expanded its program to include the routine sampling of raw milk from the four major milk producing areas supplying the State: northeast, southeast, and west Colorado, and eastern Utah. The four

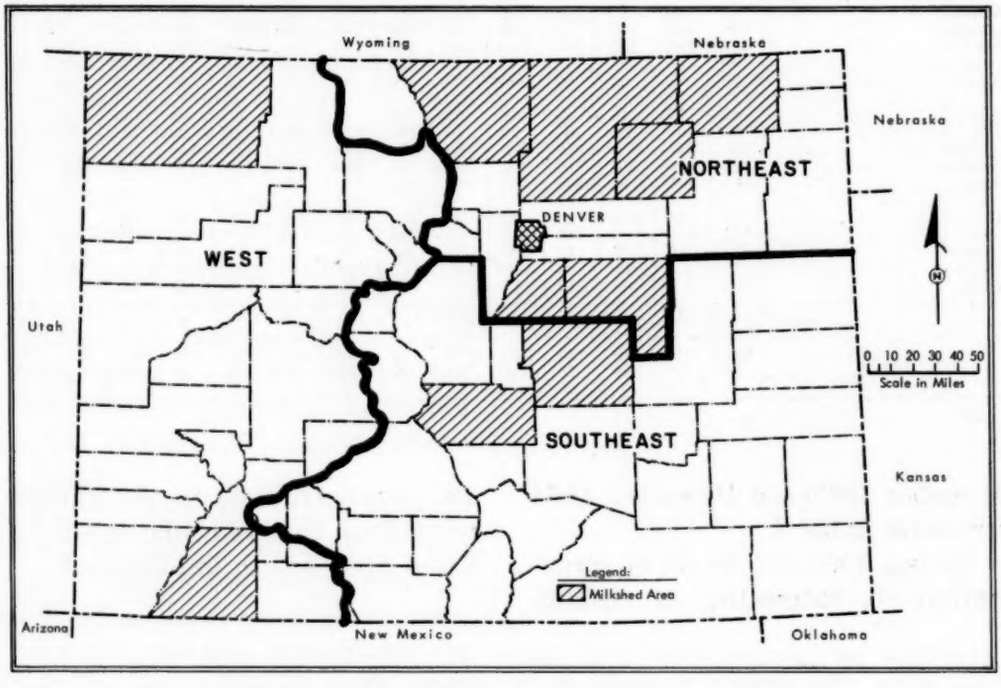

FIGURE 8. COLORADO MILK SAMPLING AREAS

major Colorado milk sampling areas are shown in figure 8. Sampling frequencies vary from one to seventeen times per month in each active sampling area. Sampling in western and southeastern Colorado was discontinued from September 1963 to June 1964.

Analytical Methods

The samples are analyzed for gamma emitting radionuclides at the State's low level counting facility. The analytical procedure utilizes an 8-foot cube steel shield having 5-inch steel walls, lined with ⅛-inch of lead. A 2-quart milk sample is gamma scanned in a stainless steel container, utilizing a 3 x 5-inch thallium-activated sodium iodide crystal detector and a 512-channel pulse height analyzer. The system is calibrated for the calculation of iodine-131, barium-140, cesium-137, and potassium-40 by a matrix method. The minimum detectable amount of the first three radionuclides is 20 pc/liter at the 95 percent confidence level (± 1.96 standard deviations).

Results and Discussion

Table 9 gives the potassium, iodine-131, and cesium-137 in milk samples collected from October 1964 through December 1964 and a summary of the results for 1962 to 1964. These data are presented graphically by area and month in figure 9.

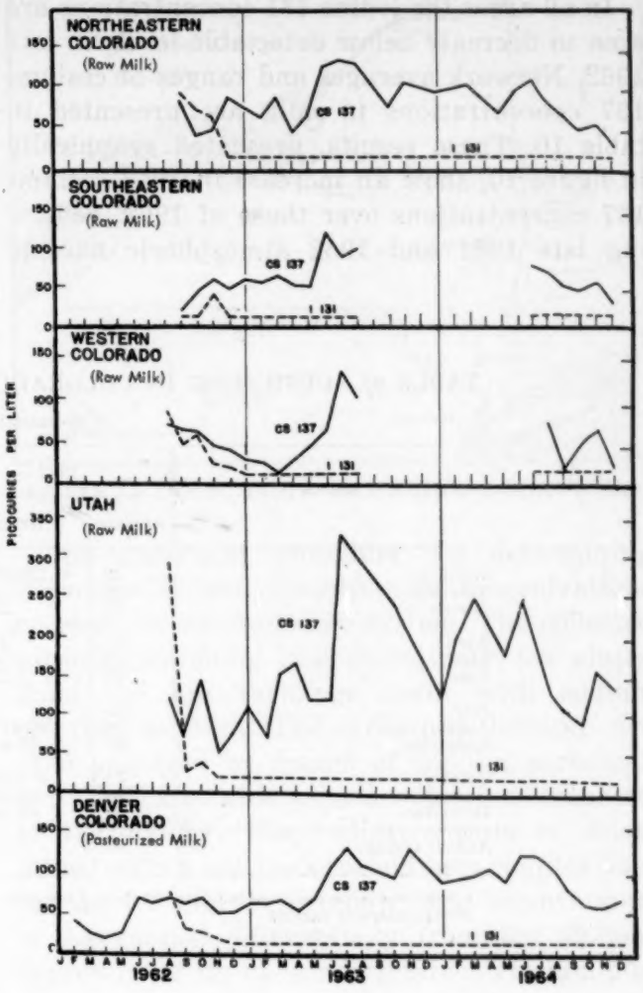

FIGURE 9. RADIONUCLIDE CONCENTRATIONS IN COLORADO MILK, 1962–1964

TABLE 9.—RADIONUCLIDES IN COLORADO MILK, OCTOBER 1964—DECEMBER 1964, AND SUMMARY[a]

[Radionuclide concentrations in pc/liter]

Date	Raw milk												Pasteurized milk		
	Northeast			Southeast			West			Eastern Utah			Denver		
	K (g/l)	I^{131}	Cs^{137}	K (g/l)	I^{131}	Cs^{137}	K (g/l)	I^{131}	Cs^{137}	K (g/l)	I^{131}	Cs^{137}	K (g/l)	I^{131}	Cs^{137}
1962 Annual Average	1.57	<57	58	1.55	25	44	1.57	51	60	1.56	<118	92	1.59	<28	50
1963 Annual Average	1.48	<20	94	1.51	<20	75	1.45	<20	60	1.50	<20	162	1.49	<20	113
1964 Quarterly Averages:															
Jan—Mar	1.28	<20	100	NS	NS	NS	NS	NS	NS	1.33	<20	193	1.32	<20	97
Apr—June	1.33	<20	83	NS	NS	NS	NS	NS	NS	1.46	<20	206	1.46	<20	109
July—Sept	1.46	<20	92	1.43	<20	67	1.20	<20	49	1.34	<20	112	1.51	<20	100
October	1.49	<20	56	1.39	<20	51	1.38	<20	57	1.54	<20	94	1.51	<20	62
November	1.26	<20	67	1.08	<20	57	1.23	24	74	1.41	<20	163	1.26	<20	61
December	1.29	<20	37	1.39	<20	25	NS	NS	NS	1.40	<20	137	1.58	<20	65
Oct—Dec	1.41	<20	56	1.31	<20	46	1.28	<20	68	1.47	<20	124	1.47	<20	63
1964 Annual Average	1.38	<20	79	1.39	<20	60	1.25	<20	60	1.41	<20	145	1.45	<20	91

NS indicates no sample collected.

[a] *Correction for previous Colorado data:* In the October 1964 issue of RHD, the "K^{40}" column in table 4 should have been labeled "K".

In all areas the iodine-131 concentrations are seen to decrease below detectable levels in late 1962. Network averages and ranges of cesium-137 concentrations in milk are presented in table 10. These results, presented graphically in figure 10, show an increase in 1963 cesium-137 concentrations over those of 1962, reflecting late 1961 and 1962 atmospheric nuclear testing. However, a decrease is seen in 1964 which can be expected to continue with the discontinuation of atmospheric nuclear testing.

Previous Coverage in Radiological Health Data:

Period	Issue
January 1962–June 1964	*October 1964*
July–September 1964	*February 1965*

TABLE 10.—CESIUM-137 IN COLORADO MILK-MONTHLY AVERAGES 1962–1964

[Concentrations in pc/liter]

Month	1962		1963		1964	
	Average	Range	Average	Range	Average	Range
January	22	[a] <20–28 (2)	61	36–100 (4)	98	94–133 (3)
February	20	40 (1)	60	30–73 (5)	115	97–211 (3)
March	27	27 (1)	74	<20–150 (5)	117	100–236 (3)
April	21	21 (1)	53	34–167 (5)	98	84–108 (3)
May	28	28 (1)	66	46–122 (5)	91	70–186 (3)
June	72	72 (1)	110	67–129 (5)	120	96–226 (3)
July	NS		152	90–326 (5)	115	75–123 (3)
August	96	70–117 (3)	115	100–130 (4)	94	68–121 (4)
September	65	22–84 (5)	NS		72	20–104 (4)
October	72	41–143 (5)	139	79–239 (3)	58	51–94 (5)
November	52	48–60 (5)	121	107–135 (2)	82	57–163 (5)
December	53	44–89 (5)	NS		62	25–137 (5)
Annual average	63	—	91	—	87	—

[a] Numbers in parentheses indicate number of samples.
NS indicates no sample.

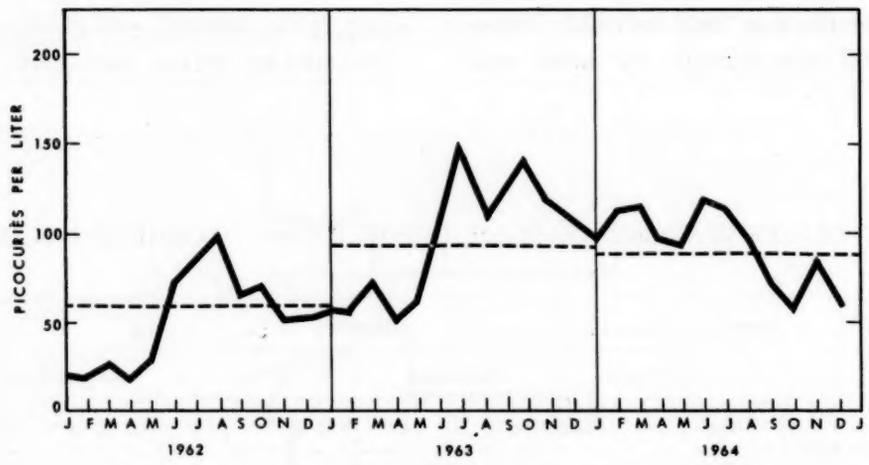

FIGURE 10. MONTHLY AVERAGE CESIUM-137 CONCENTRATIONS IN COLORADO MILK

3. New York Milk Network July–September 1964

Division of Environmental Health Services, State of New York Department of Health

Pasteurized milk samples collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 11)—are analyzed for their radionuclide content by the State of New York Department of Health. The samples are collected daily and composited weekly for the determination of strontium-89, strontium-90, iodine-131, and barium-lanthanum-140 at all stations except Massena, where samples are composited biweekly, and at New York City, where one daily milk sample representing the total milk supply for that day is obtained and analyzed once per week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are not on stored feed, the sample from Albany is analyzed daily for iodine-131. In the event that any city reports iodine-131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

Analytical Procedures

Gamma-emitting radionuclide concentrations in milk are determined by scintillation spectrometry and the application of a matrix method of analysis (*4*) to the resultant spectral data. This method is based upon the solution of simultaneous equations describing the individual spectral contributions of gamma emitting radionuclides to the total spectrum.

FIGURE 11. NEW YORK SAMPLING LOCATIONS

The analytical procedure for determining strontium-89 and strontium-90 concentrations employs an ion-exchange system. The collected cations (including radiostrontium), are eluted from the ion exchange resin with sodium chloride solution. The strontium isotopes are then gathered by means of sodium carbonate and isolated with ethylenediaminetetraacetic acid (EDTA). The radiostrontium is determined with a low background beta counter having an 0.8 mg/cm^2 window. The strontium-90 is determined differentially from the 40-hour ingrowth of its daughter product yttrium-90.

Results

The monthly average radionuclide concentrations of strontium-89, strontium-90, and cesium-137 are shown in table 11 for July 1964 to September 1964. The cesium-137 and iodine-131 concentrations since September 1961 are presented graphically in figure 12.

TABLE 11.—RADIONUCLIDE AVERAGE CONCENTRATIONS IN NEW YORK MILK [a]

[Concentrations in pc/liter]

Sampling location	Strontium-89			Strontium-90			Cesium-137		
	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept
Albany	<3	<3	<3	18	14	13	78	70	54
Buffalo	<3	<3	<3	17	13	12	84	58	56
Massena	13	3	<3	16	19	15	131	110	89
Newburgh	<3	3	4	21	19	15	99	75	66
New York City	<3	<3	6	28	19	17	111	91	64
Syracuse	<3	<3	<3	14	13	13	66	61	52
Average	4	<3	<3	19	16	14	95	78	64

[a] Monthly I^{131} and $Ba\text{-}La^{140}$ (in equilibrium) levels at each station less than the minimum detectable concentration of 20 pc/l. $Ba\text{-}La^{140}$ refers to the combined concentration of these radionuclides at equilibrium.

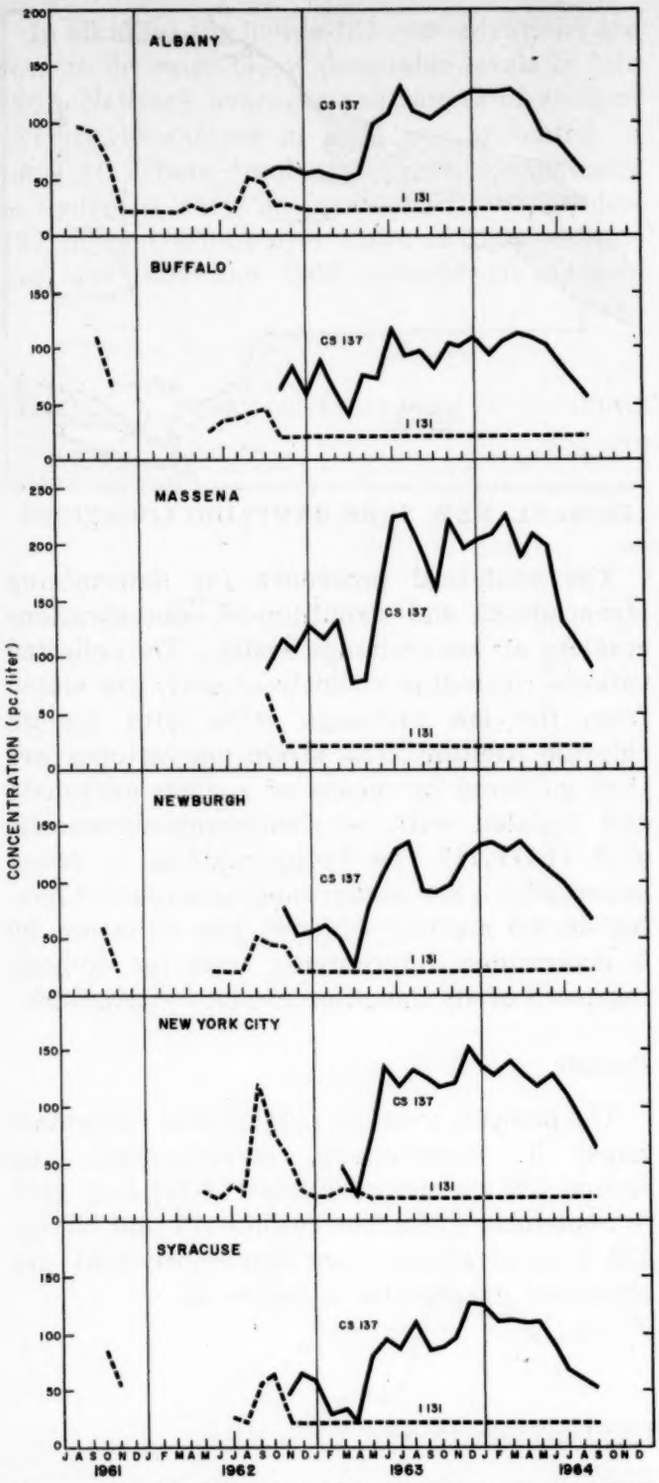
ALBANY
BUFFALO
MASSENA
NEWBURGH
NEW YORK CITY
SYRACUSE
CS 137
I 131
CONCENTRATION (pc/liter)
J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1961
1962
1963
1964

FIGURE 12. CESIUM-137 AND IODINE-131 IN NEW YORK MILK, JULY 1961-SEPTEMBER 1964

4. Canadian Milk Network[3] December 1964

Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963 liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and milk sampling locations (see figure 13) can be chosen in the same areas as the air and precipitation stations. At present the analyses include determinations of iodine-131, strontium-89, cesium-137, and strontium-90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine-131. The results of the spot checks for iodine-131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium-90, cesium-137, stable potassium and calcium.

Analytical Methods

Radiochemical methods are used for the analysis of iodine-131 (*5*). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk. The milk is then placed in a tray lined with a polyethylene sheet and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450 degrees C. and dissolved in dilute nitric acid. Strontium is separated by fuming nitric acid precipitation.

[3] Data from *Radiation Protection Programs*, Vol. 3, No. 1: 48–49, Radiation Protection Division, Canadian Department of National Health and Welfare (Jan. 1965).

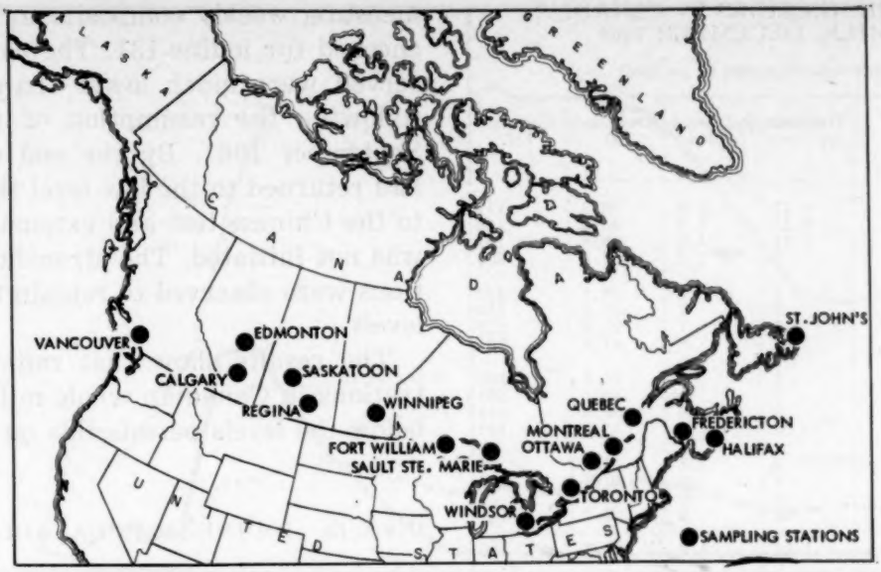

FIGURE 13. CANADIAN MILK SAMPLING STATIONS

The combined strontium-89 and strontium-90 are determined by counting in a low background beta counter. Strontium-90 is determined separately by extracting and counting its yttrium-90 daughter, while strontium-89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium-137 is determined by gamma spectroscopy using a scintillation crystal and a multichannel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium-40 and cesium-137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium-40 concentration is determined and the Compton contribution of this radionuclide to the cesium-137 photopeak is subtracted to obtain the cesium-137 concentration. The stable potassium content is estimated from the potassium-40 concentration.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium-137 this factor is not involved.

The chemical procedures error must be combined with the counting error, which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 12.

TABLE 12.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK [a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±50%	±20%	±10%
Strontium-90	±15%	±10%	±10%
Iodine-131	±25%	±20%	±15%
Cesium-137	±60%	±25%	±10%

[a] All errors are 2σ values, representing 95 percent confidence levels.

Results

Table 13 presents monthly averages of strontium-90, cesium-137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine-131 and strontium-89 indicate that all samples had < 5 pc/liter.

TABLE 13.—RADIONUCLIDES IN CANADIAN WHOLE MILK, DECEMBER 1964

[Radionuclide concentrations in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90	Cesium-137
Calgary	1.17	1.6	23.3	111
Edmonton	1.15	1.6	25.8	126
Ft. William	1.11	1.6	38.8	197
Fredericton	3	1.7	37.5	204
Halifax	7	6	36.1	242
Montreal	3	7	27.3	155
Ottawa	5	7	21.8	123
Quebec	1	6	41.8	257
Regina	3	6	31.1	125
St. John's, Nfld	3	5	34.4	200
Saskatoon	5	6	30.6	110
Sault Ste. Marie	3	7	35.9	193
Toronto	3	7	14.3	87
Vancouver	7	6	40.3	282
Windsor	3	6	13.6	78
Winnipeg	3	6	30.7	159
Average	1.14	1.6	30.2	166

Network average concentrations of stable calcium and potassium, strontium-90, and cesium-137 for 1963 and 1964 are given in table 14.

Cesium-137 levels in Canadian milk increased in the fall of 1963, but decreased in the spring of 1964 (figure 14). Strontium-89 and iodine-131 were below detectable levels during 1964, except for the period from October 19 to November 13, 1964. Iodine-131 results are shown in table 15.

After the Chinese nuclear test explosion on October 16, 1964, arrangements were made to initiate an extensive measurement program of iodine-131 in fluid milk, should this become necessary. In the meantime, as a precautionary measure, weekly composite milk samples were checked for iodine-131. The concentrations observed were much lower than those reported following the resumption of nuclear tests in September 1961. By the end of October they had returned to the low level that existed prior to the Chinese test and extensive measurement was not initiated. The strontium-89 concentrations were observed to remain below detectable levels.

The results show that radionuclide concentrations in Canadian whole milk remained well below the levels permissible on health grounds.

TABLE 15.—IODINE-131 IN CANADIAN WHOLE MILK

[Concentrations in pc/liter]

Station	Time intervals					Average
	10/19/64–10/23/64	10/26/64–10/30/64	11/2/64–11/6/64	11/9/64–11/13/64	11/16/64–11/20/64	
Calgary	0	47	8	8	N.S.	16
Edmonton	8	34	17	7	N.S.	17
Ft. William	0	58	11	5	N.S.	19
Fredericton	2	[a] N.S.	4	0	N.S.	2
Halifax	2	5	9	3	N.S.	5
Montreal	0	28	9	5	N.S.	11
Ottawa	4	[b] 7(2)	8(3)	3(3)	0(2)	5
Quebec	6	11	23	5	N.S.	11
Regina	0	8	6	1	N.S.	4
St. John's	3	16	6	6	N.S.	8
Saskatoon	0	16	11	11	N.S.	10
Sault Ste. Marie	2	27	8	2	N.S.	10
Toronto	2	27	33	12	N.S.	19
Vancouver	2	4	4	2	N.S.	3
Windsor	0	47	32	11	N.S.	23
Winnipeg	0	79	23	9	N.S.	28
Average	2	26	13	5	0	11

[a] N.S. indicates no sample collected.
[b] Parentheses indicate number of samples.

TABLE 14.—AVERAGE MONTHLY CONCENTRATIONS OF RADIONUCLIDES IN CANADIAN MILK, 1963–1964

Month	1963				1964			
	Ca (g/liter)	K (g/liter)	Sr-90 (pc/liter)	Cs-137 (pc/liter)	Ca (g/liter)	K (g/liter)	Sr-90 (pc/liter)	Cs-137 (pc/liter)
January	1.10	[a] NA	19.2	3	1.27	1.6	43.1	254
February	1.25	NA	19.1	63	1.31	1.6	41.3	250
March	1.16	NA	18.7	53	1.36	1.6	40.6	251
April	1.23	NA	17.5	80	1.38	1.6	41.5	246
May	1.13	NA	24.5	112	1.40	1.6	46.4	245
June	1.31	NA	45.2	187	1.40	1.6	42.5	227
July	1.31	NA	46.4	239	1.11	1.6	37.9	209
August	1.36	NA	52.7	260	1.10	1.6	32.5	175
September	1.31	1.5	52.3	232	1.15	1.6	31.8	147
October	1.29	1.5	45.0	203	1.15	1.6	33.7	141
November	1.25	1.4	42.3	230	1.16	1.6	33.1	143
December	1.25	1.6	40.5	245				

[a] NA indicates no analysis.

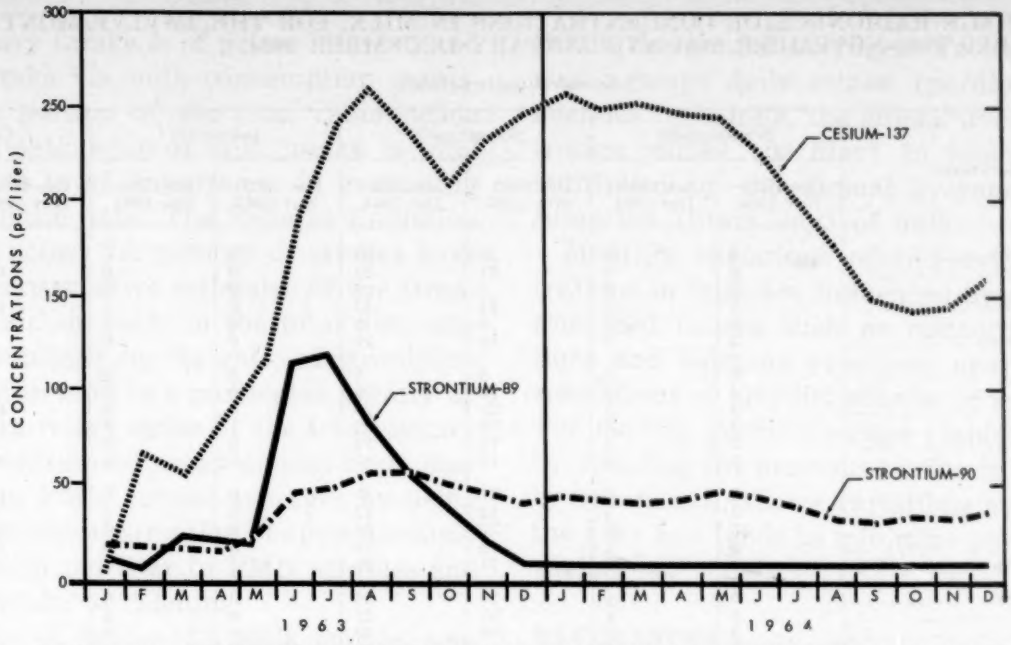

FIGURE 14. NETWORK AVERAGE STRONTUM-89, STRONTIUM-90 AND CESIUM-137 CONCENTRATIONS IN CANADIAN WHOLE MILK

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(*1*) PUBLIC HEALTH SERVICE. Summary of results from the raw milk sampling program, June 1957–April 1963. Rad Health Data 4: 511–23 (October 1963).

(*2*) PUBLIC HEALTH SERVICE. Milk surveillance, Pasteurized Milk Network, March 1964. Rad Health Data 5: 309–17 (July 1964).

(*3*) Geographical Variation in Radionuclide Content of Milk (1962). Rad Health Data 5: 185–187 (April 1963).

(*4*) KAHN, B. et al. Rapid methods for estimating fission product concentrations in milk. Public Health Service Publication No. 999–R–2 (March 1963). Single copies available on request from Public Inquiries Branch, PHS, U. S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

(*5*) DASGUPTA, A. K. and H. G. GREEN. A method for the radiochemical determination of iodine–131 in milk. RPD–23, Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada (October 1963).

APPLICATION OF RADIONUCLIDE CONCENTRATIONS IN MILK TO DOSE ASSESSMENT, JANUARY–DECEMBER 1964

Division of Radiological Health, Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) are reported on a monthly basis in *RHD*. In terms of radiological health surveillance activities, an important aspect of these data is the estimation of resultant radiation dose to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*1*) and permissible concentrations in selected environmental media (*2*). Although these guides are not themselves directly applicable to worldwide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake-dose and dose-biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Table 1 presents annual averages of radionuclide concentrations in milk sampled by the PMN. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*3,4*).

TABLE 1.—AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK, FOR THE TWELVE MONTH PERIODS,[a] DECEMBER 1963–NOVEMBER 1964 AND JANUARY–DECEMBER 1964.

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Dec 1963–Nov 1964	Jan 1964–Dec 1964	Dec 1963–Nov 1964	Jan 1964–Dec 1964	Dec 1963–Nov 1964	Jan 1964–Dec 1964	Dec 1963–Nov 1964	Jan 1964–Dec 1964
Ala:	Montgomery	3	3	23	22	0	0	82	79
Alaska:	Palmer	6	5	21	21	0	0	130	124
Ariz:	Phoenix	3	3	4	4	0	0	25	25
Ark:	Little Rock	3	3	44	43	0	1	123	117
Calif:	Sacramento	3	3	8	8	0	0	45	42
	San Francisco	3	3	10	10	0	0	51	48
C. Z:	Cristobal	3	3	5	5	0	0	51	51
Colo:	Denver	4	3	19	19	0	0	89	88
Conn:	Hartford	3	3	21	20	0	0	142	135
Del:	Wilmington	3	3	23	22	1	1	119	113
D. C:	Washington	3	3	19	19	0	0	82	79
Fla:	Tampa	3	3	15	15	0	0	232	231
Ga:	Atlanta	3	3	31	31	0	0	134	130
Hawaii:	Honolulu	3	3	12	12	0	0	77	77
Idaho:	Idaho Falls	10	10	27	26	0	0	162	154
Ill:	Chicago	3	3	19	19	0	0	112	109
Ind:	Indianapolis	3	3	21	20	1	1	95	91
Iowa:	Des Moines	5	4	25	25	0	0	87	83
Kans:	Wichita	4	4	21	21	0	0	63	63
Ky:	Louisville	3	3	30	30	0	0	86	81
La:	New Orleans	4	4	51	50	0	0	139	135
Maine:	Portland	3	3	30	29	1	1	194	187
Md:	Baltimore	3	3	22	22	0	0	96	90
Mass:	Boston	3	3	32	31	0	0	213	203
Mich:	Detroit	3	3	18	18	2	2	109	105
	Grand Rapids	3	3	21	21	1	1	120	116
Minn:	Minneapolis	7	7	32	31	0	0	141	135
Miss:	Jackson	4	4	41	40	0	0	104	99
Mo:	Kansas City	6	5	27	27	0	0	77	73
	St. Louis	5	4	23	22	0	0	78	74
Mont:	Helena	5	5	25	25	1	1	166	157
Nebr:	Omaha	5	4	26	25	0	0	90	87
Nev:	Las Vegas	3	3	10	10	1	1	72	70
N. H:	Manchester	3	3	30	30	1	1	226	217
N. J:	Trenton	3	3	19	19	1	1	112	109
N. Mex:	Albuquerque	3	3	11	11	1	1	53	53
N. Y:	Buffalo	3	3	20	20	0	0	136	131
	New York	3	3	25	25	1	1	153	146
	Syracuse[b]	3	3	20	19	0	0	134	129
N. C:	Charlotte	3	3	36	36	0	0	109	105
N. Dak:	Minot	12	11	56	54	0	0	149	147
Ohio:	Cincinnati	3	3	23	22	0	0	90	86
	Cleveland	3	3	21	21	0	0	110	107
Okla:	Oklahoma City	3	3	23	22	0	0	68	65
Ore:	Portland	6	5	30	30	0	0	154	149
Pa:	Philadelphia	3	3	20	20	0	0	115	110
	Pittsburgh	3	3	29	29	0	0	143	138
P. R:	San Juan	3	3	12	12	0	0	72	70
R. I:	Providence	3	3	24	23	0	0	157	150
S. C:	Charleston	3	3	32	32	0	0	124	122
S. Dak:	Rapid City	6	5	41	39	0	0	146	142
Tenn:	Chattanooga	4	4	41	40	0	0	116	111
	Memphis	3	3	32	32	0	0	70	68
Tex:	Austin	3	3	9	9	0	0	39	38
	Dallas	3	3	19	19	0	0	62	58
Utah:	Salt Lake City	6	6	25	25	0	0	172	165
Vt:	Burlington	3	3	26	25	2	2	170	162
Va:	Norfolk	3	3	18	18	0	0	91	88
Wash:	Seattle	7	6	26	26	0	0	146	144
	Spokane	6	6	28	28	0	0	136	132
W. Va:	Charleston	3	3	26	25	0	0	78	73
Wis:	Milwaukee	3	3	18	17	1	1	125	120
Wyo:	Laramie	8	7	20	20	0	0	104	101
Network average		4	4	24.1	23.7	0	0	113	109

[a] Annual averages were computed on basis of 52 weekly averages. Annual averages for barium-140 were all <10.
[b] Annual averages were computed on basis of 48 weekly averages for this station only as no samples were collected during July 1964.

Total dietary intake is of prime interest, and since the intake via milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*5*) notes: "A number of studies have shown that conservative estimates of the strontium-90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium-90 to calcium in milk in a particular locality by 1.5." [1] Thus, a rough index of the total dietary intake of strontium-90 on an annual basis may be made from PMN annual averages by using this factor and the assumption of approximately 1.2 g of calcium per liter in PMN samples and 1.0 g daily intake of calcium.

In the case of iodine-131, milk can be considered the major source because of the rapid distribution and consumption of fresh milk. With most other foods, normal processing and distribution allows time for this short-lived nuclide to decay to insignificant levels.

The situation with respect to strontium-89 is more complicated. Its half-life of some 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake.

The relative contribution of milk to the total dietary intake of cesium-137 is not well defined and depends principally on the amount of freshly deposited cesium-137 on products used for human and animal consumption, and the progress of cesium-137 through the food chain.

The data in table 1 are calculated as follows: results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average. [2] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of original sources of radionuclides. The moving yearly average (table 1) obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations.

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(*3*) BUREAU OF CENSUS and PUBLIC HEALTH SERVICE. National Food Consumption Survey, fresh whole milk consumption in the United States, July 1962. Rad Health Data 4:15–17 (January 1963).

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(*6*) FEDERAL RADIATION COUNCIL. Revised fallout estimates for 1964–1965 and verification of the 1963 predictions, Report No. 6. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (October 1964).

[1] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of non-milk products, whose contamination reflects temporal and local distribution patterns (6).

[2] Beginning with the October 1963 data, iodine–131 values of <10 pc/liter are considered to be zero for averaging purposes; previously, 5 pc/liter was used for calculating the averages.

COMPARISON OF RADIONUCLIDE CONCENTRATIONS IN MILK FROM DISTRIBUTORS SERVING THE CITY OF BOSTON

E. J. Baratta,[1] *M. A. Wall,*[2] and *H. Mazer*[3]

Introduction

The Public Health Service Pasteurized Milk Network, (PMN) established in 1960, monitors the radionuclide content of fluid milk consumed in 63 cities in the United States. Sampling procedures were designed to include a sufficient number of distributors to assure that the samples collected were representative of the milk being consumed. At most stations the actual sample represents from 80 to 100 percent of the milk processed in the area (*1*) and, ideally, the sample is composited by drawing from each of the distributors a volume proportional to its share of the market.

The purpose of this study was to compare the radionuclide content of milk from each of the six major distributors, who supply a total of 99 percent of the fluid milk consumed in the city of Boston, with that of the local sample collected for the Pasteurized Milk Network. Such a comparison would indicate whether the reported PMN average radionuclide content was representative of the milk consumed by an individual customer of any one of the six major distributors.

Three of the six companies supply about 82 percent of the milk consumed in Boston. All six distributors are served by dairy farms in Maine, New Hampshire, Vermont, Massachusetts, and New York. As would be expected, there is considerable overlap of their respective milksheds.

The best sampling procedure would be one that obtained an "ideal" sample, composited from samples from the six distributors, weighted according to their respective outputs. When this study was initiated, the Network station sample consisted of equal parts from the three dealers selling 82 percent of the milk, on the assumption that each sold about 27 percent of the total volume. Since this was not the actual situation, an auxiliary purpose of this study was to investigate the validity of the sampling procedure, in order to determine whether the radionuclide content in the Network sample approximated that of an ideal sample.

Data Collection and Presentation

The study was conducted from January to December 1963 and weekly samples were collected from each of the six companies. To reduce the analytical work-load, four consecutive weekly samples from each distributor were composited and analyzed for strontium-90, cesium-137, and strontium-89, the three fallout nuclides present in detectable amounts at the time of the study.

The results of the strontium-90 determinations in all samples are shown in table 1. By using the data for the *three* largest companies, a calculated *weighted* average (proportional to the milk volume as distributed) and an *unweighted* calculated average were obtained. Calculated *weighted* averages for all *six* distributors also appear in the table. Similar data for cesium-137 and strontium-89 are shown in tables 2 and 3, respectively.

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TABLE 1.—STRONTIUM-90 IN BOSTON MILK, BY DISTRIBUTOR—1963

[Concentrations in pc/liter]

Sampling period	Distributor						Network station sample average	Calculated average of three largest distributors		Calculated average of six major distributors (Weighted)
	A	B	C	D	E	F		Unweighted	Weighted	
1/2–1/25	13.6	15.9	25.7	13.5	21.6	23.7	18.2	18.4	17.7	18.1
1/29–2/19	15.6	18.4	19.9	21.4	10.8	12.3	15.1	18.0	17.5	17.0
2/26–3/19	20.7	22.2	17.9	13.9	14.9	19.5	23.8	20.3	20.2	19.4
3/26–4/16	11.3	15.1	10.4	24.2	14.6	14.9	22.1	12.3	11.9	12.9
4/23–5/14	17.4	19.6	18.4	15.2	18.6	23.0	17.1	18.5	18.2	18.3
5/21–6/11	41.0	43.6	51.6	35.3	41.6	49.3	37.8	45.5	44.8	44.3
6/18–7/9	35.6	45.2	54.7	44.0	39.3	35.7	50.7	45.2	43.4	42.8
7/16–8/6	46.6	50.3	45.7	34.5	40.2	46.3	52.0	47.5	47.1	45.9
8/13–9/3	41.5	50.7	46.5	39.5	39.0	49.0	43.6	46.2	45.0	44.6
9/10–10/1	35.1	45.0	38.2	35.0	31.0	43.2	38.5	39.4	38.2	37.9
10/8–10/29	35.4	41.6	36.5	45.2	34.6	58.7	35.8	37.8	37.1	38.7
11/5–11/26	31.8	38.9	35.8	38.2	29.2	41.6	37.3	35.5	34.6	34.9
12/3–12/23	30.6	42.0	39.0	42.0	30.0	48.5	34.8	37.2	33.9	36.5
1963 Avg	28.9	34.5	33.9	30.9	28.1	35.8	32.8	32.4	31.6	31.6

TABLE 2.—CESIUM-137 IN BOSTON MILK, BY DISTRIBUTOR—1963

[Concentrations in pc/liter]

Sampling period	Distributor						Network station sample average	Calculated average of three largest distributors		Calculated average of six major distributors (Weighted)
	A	B	C	D	E	F		Unweighted	Weighted	
1/2–1/25	DATA NOT AVAILABLE						100.7			
1/29–2/19	83.2	82.1	85.0	107.6	84.1	125.9	88.8	83.4	83.5	87.5
2/26–3/19	91.8	96.3	102.4	64.0	74.2	115.5	97.4	96.8	96.0	99.1
3/26–4/16	101.0	87.5	72.5	67.0	74.7	115.7	89.2	87.0	89.5	88.7
4/23–5/14	92.6	98.7	114.8	81.7	105.6	88.4	99.4	102.0	100.6	99.1
5/21–6/11	150.8	205.7	179.1	151.8	189.6	194.8	197.8	178.5	171.4	172.8
6/18–7/9	293.5	294.8	342.2	231.8	289.0	233.6	298.8	310.1	308.4	298.3
7/16–8/6	368.5	370.9	406.8	244.3	315.9	355.2	361.4	382.1	380.5	367.1
8/13–9/3	330.8	449.3	358.3	263.0	315.1	392.9	391.9	379.5	365.1	357.7
9/10–10/1	238.7	312.8	256.5	223.7	226.3	339.6	269.8	269.3	260.3	260.9
10/8–10/29	229.6	277.8	219.9	239.6	317.3	216.2	236.1	242.4	237.3	240.1
11/5–11/26	236.7	263.5	250.7	216.2	233.0	268.8	258.9	250.3	246.8	245.5
12/3–12/23	220.6	305.4	277.6	259.2	246.2	353.9	263.2	267.9	256.4	262.0
1963 Avg	203.1	237.1	222.1	179.2	205.9	233.4	211.8	220.8	216.3	214.5

TABLE 3.—STRONTIUM-89 IN BOSTON MILK, BY DISTRIBUTOR—1963

[Concentrations in pc/liter]

Sampling period	Distributor						Network station sample average	Calculated average of three largest distributors		Calculated average of six major distributors (Weighted)
	A	B	C	D	E	F		Unweighted	Weighted	
1/2–1/25	9.6	4.3	15.2	5.4	4.7	4.2	4.8	9.7	10.1	9.2
1/29–2/19	2.5	0.7	0.0	0.0	1.6	7.1	4.6	1.1	1.4	1.6
2/26–3/19	0.0	0.3	0.1	2.3	4.5	5.5	2.1	0.1	0.1	0.8
3/26–4/16	4.4	1.0	6.8	0.0	6.5	6.0	0.6	4.1	4.4	4.4
4/23–5/14	6.9	34.4	9.0	16.2	12.2	2.6	11.4	16.8	13.4	13.0
5/21–6/11	52.3	69.5	47.2	45.1	41.9	32.6	71.9	56.3	54.6	51.9
6/18–7/9	68.1	77.7	101.3	70.8	79.5	62.1	76.9	82.4	80.2	78.6
7/16–8/6	80.1	81.8	91.9	68.3	69.4	80.3	82.8	84.6	84.0	82.0
8/13–9/3	75.8	65.5	63.0	63.6	49.8	59.8	75.3	68.1	69.7	70.5
9/10–10/1	31.3	35.0	31.0	32.9	26.1	49.8	39.4	32.4	32.0	32.9
10/8–10/29	44.7	13.2	14.2	11.4	34.6	58.7	23.2	24.0	28.6	29.6
11/5–11/26	9.8	7.7	13.2	15.2	10.5	3.0	10.7	10.2	10.4	10.2
12/3–12/23	6.2	2.2	3.0	0.0	6.6	5.2	4.7	3.8	4.4	4.3
1963 Avg	30.1	30.3	30.5	25.5	26.8	29.0	31.4	30.3	30.3	29.7

The individual analytical results for strontium-90 in fluid milk from each of the six distributors are plotted in figure 1. Similar cesium-137 and strontium-89 data are shown in figures 3 and 5. Comparisons of the strontium-90 content of the Network sample with the calculated averages for the three major companies, both weighted and unweighted, and with the calculated weighted average for all six companies are presented in figure 2. Similar comparisons for cesium-137 and strontium-89 are shown in figures 4 and 6.

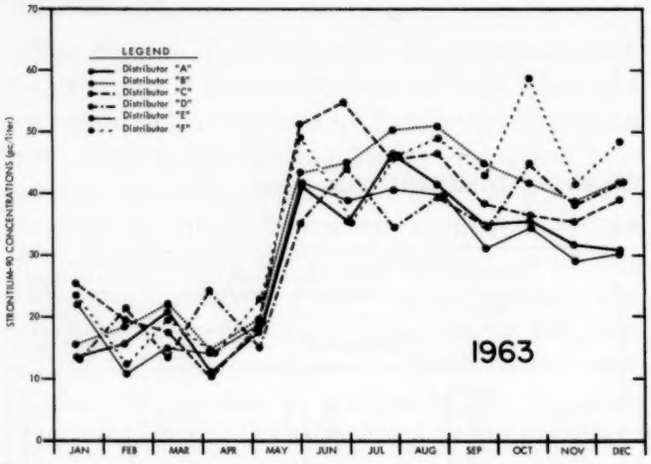

FIGURE 1. CONCENTRATIONS OF STRONTIUM-90 IN MILK FROM INDIVIDUAL DISTRIBUTORS

Discussion of Results

On the basis of the data presented, it is apparent (figures 1, 3, and 5) that the general month-by-month trend of radionuclide levels for milk from all six distributors was similar. For all companies there was a distinct rise in the concentrations of strontium-90, cesium-137, and strontium-89 about the first of May. A decline in strontium-89 levels began in late July or early August, while the cesium-137 decline began about one month later. The strontium-90 concentrations observed in the summer remained at roughly the same levels throughout the rest of the year. A rise in the strontium-89 and strontium-90 concentrations during the month of October was observed in milk from several of the distributors. Although the reason for this is not clear, it may be that the cows were able to graze on open pasture during this time due to mild weather.

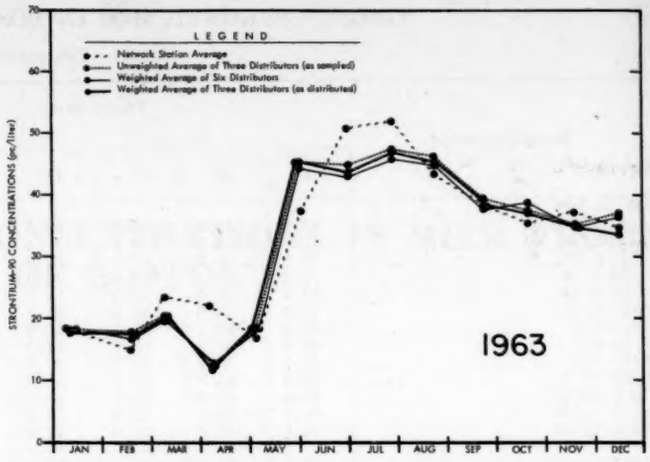

FIGURE 2. COMPARISON OF STRONTIUM-90 CONCENTRATIONS IN MILK FROM INDIVIDUAL DISTRIBUTORS WITH THOSE OF THE NETWORK STATION SAMPLE

The most valid comparison of the data is on the basis of yearly averages. This minimizes seasonal variation and reduces the effect of analytical errors. This is also in accordance with the recommendations of the Federal Radiation Council (2). The highest yearly average for the strontium-90 content in milk from any single dealer (tables 1, 2, and 3) was 35.8 pc/l (Distributor F), only 9 percent above the average for the Network station sample. The lowest yearly average (Distributor E) was only 15 percent below the average for the Network station sample. For cesium-137 the extremes were 11 percent above (Distributor B) and 15 percent below (Distributor D) the Network station sample. The strontium-89 extremes were 18 percent above and 3 percent below for Distributors D and C, respectively.

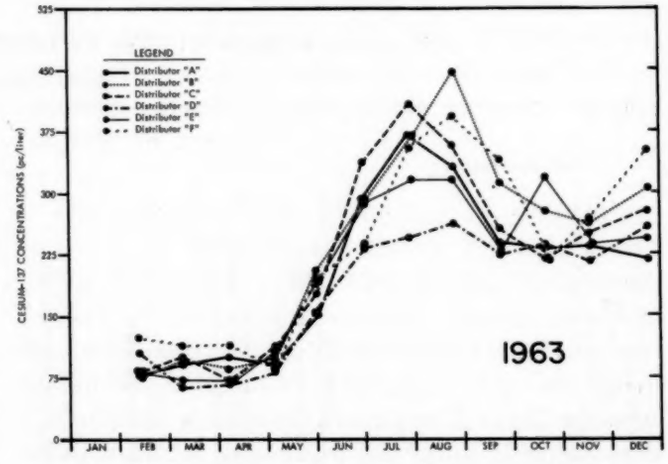

FIGURE 3. CONCENTRATIONS OF CESIUM-137 IN MILK FROM INDIVIDUAL DISTRIBUTORS

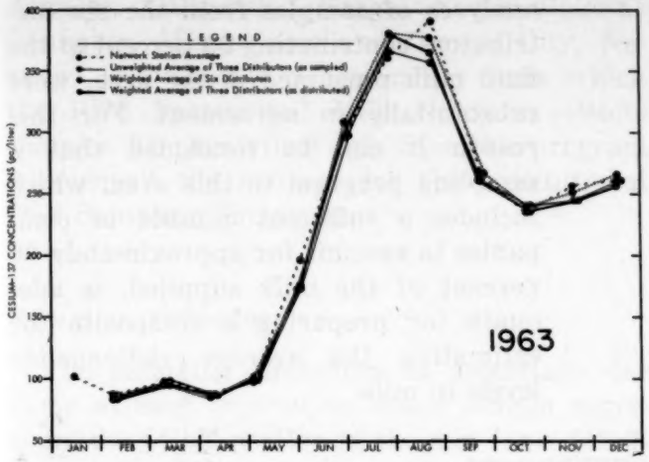

FIGURE 4. COMPARISON OF CESIUM–137 CONCENTRATIONS IN MILK FROM INDIVIDUAL DISTRIBUTORS WITH THOSE OF THE NETWORK STATION SAMPLE

The data demonstrate that the sampling technique used during the period of the study was not a source of appreciable error. Figures 2, 4, and 6 show that the calculated *monthly* averages for the three milk companies, both weighted and unweighted, were remarkably close to the values for the Network station sample. More important, these data closely corresponded to the calculated weighted averages for the milk from all six companies. On the basis of these data, it is apparent that the Network station sample, consisting of equal portions from each of the three major distributors, was adequate during the period of the study.

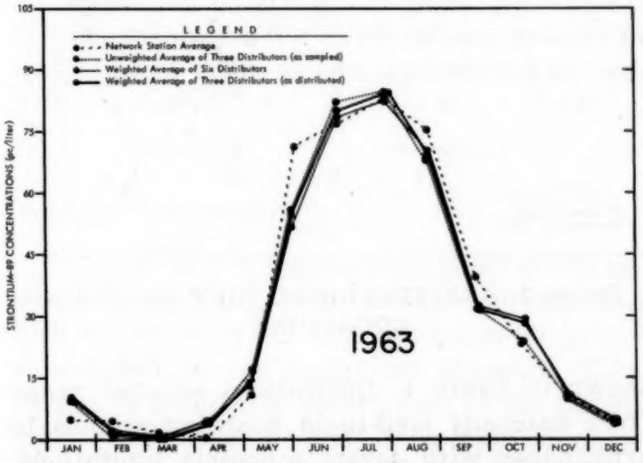

FIGURE 6. COMPARISON OF STRONTIUM–89 CONCENTRATIONS IN MILK FROM INDIVIDUAL DISTRIBUTORS WITH THOSE OF THE NETWORK STATION SAMPLE

There was remarkably close agreement for the three radionuclides between the yearly averages of the Network station sample and all of the corresponding calculated *yearly* averages, including the weighted and unweighted averages for the three largest distributors (A, B, and C) and the weighted average for the six distributors (A through F). For strontium-90 the calculated yearly average (unweighted) for the three largest companies was the same as the yearly average for the Network station sample (table 1). The comparable value for cesium-137 was 5 percent, and the calculated yearly average weighted for the six companies was only 3 percent, above the yearly average of the Network station sample (table 2). The strontium-89 calculated yearly averages were within 4 percent of the Network yearly average (table 3).

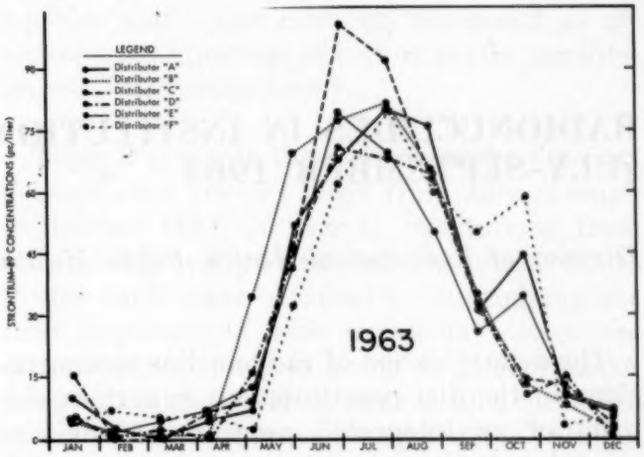

FIGURE 5. CONCENTRATIONS OF STRONTIUM–89 IN MILK FROM INDIVIDUAL DISTRIBUTORS

Conclusions

On the basis of these data it can be stated that, during the period of the study, in the city of Boston:

1. There was reasonably close agreement between the yearly average levels of strontium-90, cesium-137, and strontium-89 in the Network station sample and in the milk from each of the six major distributors serving the area. For this reason, it can be concluded that the Network station sample offered a good estimate of the radionuclide content of the fluid milk supplied by the individual companies commercially serving the city.

2. There was very close agreement between the yearly average levels for strontium-90, cesium-137, and strontium-89 in the Network station sample and the calculated averages based on the data from the individual analyses of the samples from the three major distributors, weighted according to the volume of milk distributed. Therefore, it can be concluded that the compositing procedure employed by the Pasteurized Milk Network, though not ideal, was adequate under the circumstances.

3. The yearly average levels of strontium-90, cesium-137, and strontium-89 in the Network station sample and in the weighted yearly averages, calculated from the data from the individual analyses of samples from the six distributors contributing 99 percent of the fluid milk consumed in the area, were substantially in agreement. For this reason it can be concluded that a sampling program in this area, which includes a sufficient number of companies to account for approximately 80 percent of the milk supplied, is adequate for preparing a composite for estimating the average radionuclide levels in milk.

REFERENCES

(*1*) DIVISION OF RADIOLOGICAL HEALTH. Pasteurized Milk Network. Rad Health Data, 5: 257 (June 1964).
(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES, JULY–SEPTEMBER 1964

Division of Radiological Health, Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program is designed to estimate the dietary intake of radionuclides in a selected population group of children ranging up to 19 years of age. Initially, the program consisted of sampling diets in eight institutions, but it has since been expanded to 41 boarding schools or institutions, geographically distributed as shown in figure 1. Institutions selected range from fiancially well-to-do boarding schools to orphanages with severe economic limitations. Each institution (with the exception of Los

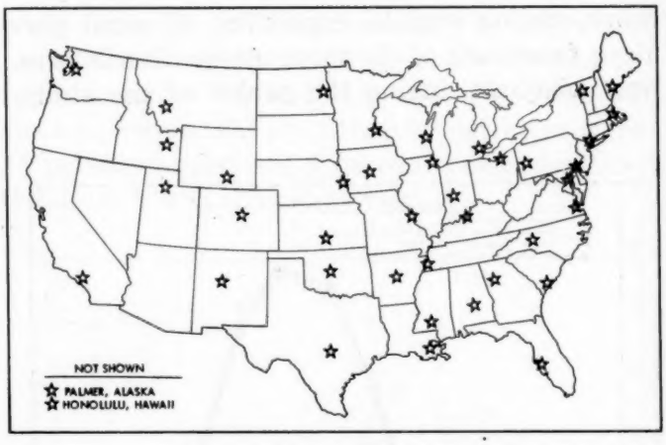

FIGURE 1. INSTITUTIONAL DIET SAMPLING LOCATIONS

Angeles, California; Fargo, North Dakota; Columbia, Mississippi; and Carson City, Nevada) is located in a community from which the PHS Pasteurized Milk Network collects samples. The analytical data from this program supplement the findings for the Institutional Diet Sampling Program.

Sampling Procedure

The sampling procedure is essentially the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Each institution supplies one complete 7-day, 21-meal diet sample each month. Each day's sample is kept frozen during the collection period. After collection the total sample is packed in dry ice for shipment by air express to the Southwestern Radiological Health Laboratory, Las Vegas, Nevada; the Southeastern Radiological Health Laboratory, Montgomery, Alabama; or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

The sample for each day is packaged in three parts: (1) solid food and semisolid foods minus those portions that would not ordinarily be eaten; (2) liquid milk; (3) other beverages such as soft drinks, coffee, and tea. Drinking water is not included in these samples or recorded in this report. A record of the contents of each meal and the approximate amount of each item is made at the institution and sent with the sample.

Analytical Procedures

Because calcium may have an effect on the uptake of important bone-seeking radionuclides such as strontium-89 and strontium-90 (*2*), it is included in the analytical program. Total weight is accurately determined in the laboratory. Stable calcium and stable potassium determinations are obtained by conventional gravimetric or spectrophotometric methods. Samples usually range from 6 to 16 liters in volume and weigh from 8 to 20 kilograms.

The radioanalysis program is designed around three basic procedures: (1) gamma spectroscopy; (2) chemical separation of strontium-89 and strontium-90 with subsequent counting; and (3) radium-226 analysis. In the absence of interferences other than that from naturally-occurring radioactive potassium (K^{40}), minimum detectable concentrations for the gamma scan for iodine-131, cesium-137, and barium-140 are 10 pc/kg. Approximate minimum detectable concentrations for strontium-89, strontium-90, and radium-226 are: 5, 1, and 0.1 pc/kg, respectively.

Data

Table 1 gives the results of the laboratory analyses of the food samples. In this table are presented concentrations of various radionuclides and stable elements expressed as picocuries per kilogram of diet or grams per kilogram of diet, respectively.

Table 2 presents the dietary intake data expressed on a per-day basis from July through September 1964 for the 41 institutions from which samples were received. The intake values in this table were obtained by multiplying the food consumption rate in kg/day times the concentration values in grams or picocuries per kilogram of diet given in table 1. Also contained in the table is the range of ages of the children from which samples were obtained each month. The reported radionuclide concentrations of these samples are extrapolated to the midpoint of the sample collection period.

Certain of the radioanalyses are reported by the laboratories as being "less-than" (<) a specified value. For data computations, the method employed is to use a zero for <10 pc/kg values for iodine-131 and barium-140. A 2.5 pc/kg value was substituted for a <5 pc/kg of strontium-89.

Recent coverage in *Radiological Health Data:*

Period	*Issue*
July–September 1963	*March 1964*
October–December 1963	*July 1964*
January–March 1964	*October 1964*
April–June 1964	*January 1965*

TABLE 1.—INSTITUTIONAL DAILY DIETARY INTAKE CONCENTRATIONS, THIRD QUARTER 1964

Location of institution	1964	Age (years)	Total weight (kg/day)	Calcium (g/kg)	Potassium (g/kg)	Radionuclide concentrations (picocuries/kg)					
						Radium-226 [a]	Strontium-89	Strontium-90	Cesium-137	Barium-140	Iodine-131
Ala., Montgomery	July	11–16	1.88	0.5	0.9	NA	5	13	50	<10	<10
	Aug	15–17	2.20	0.5	1.2	NA	<5	12	40	<10	<10
	Sept	15–17	2.23	0.5	1.0	NA	<5	9	50	<10	<10
Alaska, Palmer	July	10–16	1.60	0.6	1.5	0.4	5	24	100	<10	<10
	Aug	10–11	1.66	0.6	1.0	2.0	5	15	80	<10	<10
	Sept	11	1.63	0.3	1.1	0.7	<5	16	100	<10	<10
Ark., Little Rock	July	7–12	1.69	0.4	1.2	NA	5	22	50	<10	<10
	Aug	8–12	1.68	0.5	1.1	NA	<5	21	60	<10	<10
	Sept	10–12	1.67	0.7	1.0	NA	<5	29	45	<10	<10
Calif., Los Angeles	July	NS	[a] NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Sept	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
Colo., Denver	July	10–17	2.50	0.5	1.4	0.7	<5	16	90	<10	<10
	Aug	10–17	2.53	0.6	1.4	1.3	5	16	70	<10	<10
	Sept	10–17	2.21	0.5	1.5	1.1	<5	7	50	<10	<10
Conn., Hartford	July	1–18	1.88	0.6	1.4	0.6	<5	14	90	<10	<10
	Aug	1–15	1.76	0.6	1.7	0.6	<5	12	100	<10	<10
	Sept	14–19	2.04	0.6	1.4	0.5	<5	10	70	<10	<10
Del., Wilmington	July	11–13	1.87	0.7	1.3	0.2	<5	13	70	<10	<10
	Aug	10–12	1.23	[b] NA	1.4	0.6	<5	14	70	<10	<10
	Sept	11–12	1.92	1.0	1.7	0.9	<5	17	70	<10	<10
Fla., Tampa	July	7–17	1.73	0.6	1.0	NA	<5	12	115	<10	<10
	Aug	9–16	1.81	0.6	0.9	NA	<5	11	120	<10	<10
	Sept	10–12	2.24	0.7	0.9	NA	<5	13	145	<10	<10
Ga., Atlanta	July	7–16	1.50	0.5	1.1	NA	<5	21	55	<10	<10
	Aug	6–17	1.82	0.4	1.1	NA	<5	18	50	<10	<10
	Sept	5–15	1.74	0.5	1.2	NA	<5	19	65	<10	<10
Hawaii, Honolulu	July	6–10	1.82	0.4	1.1	1.0	<5	8	65	<10	<10
	Aug	15–19	1.66	0.5	1.2	0.5	<5	10	65	<10	<10
	Sept	15–19	1.74	0.4	1.3	1.3	<5	6	60	<10	<10
Idaho, Idaho Falls	July	15–17	2.12	0.7	1.6	0.5	<5	22	125	<10	<10
	Aug	16–17	1.77	0.5	1.4	0.4	<5	20	95	<10	<10
	Sept	14–17	2.07	0.6	1.7	0.2	<5	24	120	<10	<10
Ill., Chicago	July	10–12	1.75	0.8	1.5	0.6	<5	14	85	<10	<10
	Aug	11–12	1.70	0.7	1.5	0.7	<5	15	75	<10	<10
	Sept	11–14	1.85	0.7	1.5	0.7	<5	8	70	<10	<10
Ind., Indianapolis	July	4–11	1.35	0.8	1.4	0.7	<5	15	60	<10	<10
	Aug	7–16	1.84	0.7	1.6	0.7	<5	11	60	<10	<10
	Sept	15–16	1.87	0.9	1.5	0.8	<5	14	60	<10	<10
Iowa, Des Moines	July	5–12	2.06	0.8	1.1	NA	5	23	55	<10	<10
	Aug	5–13	2.37	0.8	1.1	NA	<5	19	60	<10	<10
	Sept	15–17	2.43	0.7	1.0	NA	<5	18	60	<10	<10
Kans., Wichita	July	13	1.88	0.6	1.0	NA	<5	14	30	<10	<10
	Aug	10	1.86	0.6	1.3	NA	<5	12	80	<10	<10
	Sept	12	1.92	0.7	1.3	NA	<5	17	45	<10	<10
Ky., Louisville	July	15–18	2.26	0.4	0.9	NA	5	14	40	<10	<10
	Aug	15–16	2.50	0.8	1.2	NA	<5	24	45	<10	<10
	Sept	15–17	1.98	0.7	1.1	NA	<5	19	30	<10	<10
La., New Orleans	July	12	2.59	0.6	1.3	NA	10	31	80	<10	<10
	Aug	13–15	2.63	0.6	1.1	NA	<5	26	65	<10	<10
	Sept	11–15	2.45	0.6	1.3	NA	<5	21	60	<10	<10
Maine, Portland	July	10–16	2.18	0.6	1.5	0.4	<5	21	150	<10	<10
	Aug	10–19	2.09	0.8	1.3	0.9	<5	23	130	<10	<10
	Sept	15–17	2.39	0.7	1.5	0.8	<5	15	95	<10	<10
Md., Baltimore	July	7–15	2.04	0.7	1.3	NA	<5	21	80	<10	<10
	Aug	8–15	2.12	0.7	1.1	NA	<5	18	55	<10	<10
	Sept	11–12	2.11	0.7	1.1	NA	<5	18	45	<10	<10
Mass., Boston	July	9–11	1.71	0.8	1.4	0.5	<5	18	155	<10	<10
	Aug	11–13	1.85	0.7	1.5	0.6	<5	21	125	<10	<10
	Sept	10–13	1.06	0.6	1.5	0.7	<5	14	110	<10	<10
Mich., Detroit	July	7–14	1.74	0.6	1.2	1.0	<5	11	75	<10	<10
	Aug	9–15	1.96	0.8	1.6	0.7	<5	13	90	<10	<10
	Sept	10–15	2.23	0.8	1.4	0.7	<5	8	70	<10	<10
Minn., Minneapolis	July	2–8	1.98	0.5	1.3	0.6	<5	17	75	<10	<10
	Aug	2–8	1.56	0.6	1.1	0.7	<5	17	80	<10	<10
	Sept	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
Miss., Columbia	July	14–17	2.14	0.8	1.2	NA	15	34	105	<10	<10
	Aug	15–17	1.86	0.9	1.2	NA	<5	27	85	<10	<10
	Sept	12–18	1.61	0.9	1.0	NA	<5	28	65	<10	<10
Mo., St. Louis	July	8–15	2.58	0.7	1.4	0.9	5	18	50	<10	<10
	Aug	7–13	2.56	0.6	1.4	0.9	<5	17	55	<10	<10
	Sept	13–18	1.86	0.5	1.1	0.8	<5	6	55	<10	<10

TABLE 1.—INSTITUTIONAL DAILY DIETARY INTAKE CONCENTRATIONS, THIRD QUARTER 1964—Continued

Location of institution	1964	Age (years)	Total weight (kg/day)	Calcium (g/kg)	Potassium (g/kg)	Radionuclide concentrations (picocuries/kg)					
						Radium-226 [a]	Strontium-89	Strontium-90	Cesium-137	Barium-140	Iodine-131
Mont., Helena	July	7–17	1.87	0.5	1.2	0.7	<5	14	80	<10	<10
	Aug	10–16	1.80	0.4	1.0	0.6	<5	13	65	<10	<10
	Sept	17	1.97	0.3	1.1	0.6	<5	14	75	<10	<10
Nebr., Omaha	July	10–14	2.39	0.0	1.6	0.2	5	22	75	<10	<10
	Aug	10–17	1.84	0.8	1.2	0.6	5	18	50	<10	<10
	Sept	15–17	1.91	0.6	1.1	1.1	<5	21	45	<10	<10
Nev., Carson City	July	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Sept	15–17	2.41	0.5	1.5	0.2	<5	23	50	<10	<10
N. J., Trenton	July	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	16	2.26	0.4	1.3	1.5	<5	16	55	<10	<10
	Sept	15	2.44	0.5	1.2	1.0	<5	9	50	<10	<10
N. Mex., Albuquerque	July	5–11	1.74	0.9	1.4	0.9	<5	14	50	<10	<10
	Aug	5–11	1.83	0.3	1.6	0.6	<5	4	50	<10	<10
	Sept	5–11	2.08	0.5	1.4	0.5	<5	8	40	<10	<10
N. Y., New York	July	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Sept	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
N. C., Charlotte	July	8–17	1.73	0.5	0.9	NA	<5	19	45	<10	<10
	Aug	7–14	1.88	0.6	1.0	NA	<5	26	50	<10	<10
	Sept	16–17	1.59	0.7	1.1	NA	<5	28	45	<10	<10
N. D., Fargo	July	9–16	1.70	0.9	1.4	0.1	<5	15	110	<10	<10
	Aug	10–16	1.06	1.2	1.4	2.0	<5	18	35	<10	<10
	Sept	10–12	1.44	0.6	1.6	0.6	<5	16	80	<10	<10
Ohio, Cleveland	July	6–12	2.01	0.7	1.5	0.4	<5	14	80	<10	<10
	Aug	6–12	1.82	0.6	1.8	0.7	<5	12	80	<10	<10
	Sept	10–12	1.67	0.7	1.5	0.7	<5	12	70	<10	<10
Okla., Oklahoma City	July	15–19	1.76	0.4	0.8	NA	<5	8	35	<10	<10
	Aug	12–14	2.22	0.4	0.8	NA	<5	8	20	<10	<10
	Sept	11–14	1.41	0.6	0.8	NA	<5	15	45	<10	<10
Ore., Portland	July	14–17	2.25	0.5	1.1	0.3	<5	13	55	<10	<10
	Aug	13–16	2.03	0.3	1.0	0.5	<5	12	55	<10	<10
	Sept	13–17	1.85	0.3	1.4	0.5	<5	20	70	<10	<10
Penn., Pittsburgh	July	14	2.26	0.6	1.4	0.5	<5	17	85	<10	<10
	Aug	14	2.33	0.6	1.4	0.8	<5	16	80	<10	<10
	Sept	15–16	2.06	0.6	1.4	0.7	<5	14	65	<10	<10
S. C., Charleston	July	14	1.70	0.4	1.1	NA	<5	16	55	<10	<10
	Aug	8	1.67	0.5	1.1	NA	<5	12	60	<10	<10
	Sept	10–14	1.92	0.6	1.1	NA	<5	22	75	<10	<10
Tenn., Memphis	July	14–17	1.48	0.7	1.3	NA	<5	23	40	<10	<10
	Aug	14–17	1.64	0.6	1.0	NA	<5	29	40	<10	<10
	Sept	14–17	1.64	0.6	1.0	NA	<5	20	40	<10	<10
Texas, Austin	July	13–19	2.12	0.5	1.0	NA	<5	10	35	<10	<10
	Aug	15–17	1.90	0.5	0.9	NA	<5	16	25	<10	<10
	Sept	13–15	1.97	0.5	0.9	NA	<5	11	35	<10	<10
Utah, Salt Lake City	July	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Sept	16	1.85	0.5	1.5	0.6	<5	21	80	<10	<10
Vt., Burlington	July	6–16	1.47	1.0	1.5	0.9	<5	20	105	<10	<10
	Aug	7–12	1.68	0.5	1.6	0.4	<5	19	95	<10	<10
	Sept	10–12	1.55	0.5	1.6	1.8	<5	12	85	<10	<10
Va., Norfolk	July	11–17	1.20	0.5	1.2	NA	5	18	60	<10	<10
	Aug	11–15	2.27	0.5	1.0	NA	<5	16	50	<10	<10
	Sept	15–17	2.46	0.5	0.9	NA	<5	13	55	<10	<10
Wash., Seattle	July	15–17	2.46	0.7	1.5	0.6	<5	26	140	<10	<10
	Aug	15–17	2.36	0.7	1.2	1.1	<5	22	120	<10	<10
	Sept	17	2.07	0.4	1.7	0.8	<5	11	120	<10	<10
W. Va., Charleston	July	10–12	1.80	0.6	1.2	NA	<5	23	60	<10	<10
	Aug	10–12	2.08	0.5	1.0	NA	<5	23	60	<10	<10
	Sept	10–12	2.03	0.5	0.9	NA	<5	18	40	<10	<10
Wis., Milwaukee	July	5–16	1.53	0.7	1.5	0.2	<5	8	85	<10	<10
	Aug	15–17	2.67	0.6	1.4	0.7	<5	13	75	<10	<10
	Sept	15–17	2.31	0.8	1.4	0.6	<5	11	70	<10	<10
Wyo., Laramie	July	13–17	1.96	0.6	1.3	0.8	<5	20	65	<10	<10
	Aug	11–14	1.90	0.6	1.3	1.1	<5	22	60	<10	<10
	Sept	11	1.16	0.3	1.6	1.0	<5	13	55	<10	<10
Monthly averages	July		1.94	0.6	1.3	0.6	<5	17	75	<10	<10
	Aug		1.95	0.6	1.2	0.8	<5	17	70	<10	<10
	Sept		1.93	0.6	1.3	0.8	<5	16	65	<10	<10

[a] Average for radium-226 does not include total radium.
[b] NS indicates no sample.
[c] NA indicates no analysis.

TABLE 2.—INSTITUTIONAL DAILY DIETARY INTAKE, THIRD QUARTER 1964

Location of institution	1964	Age (years)	Total weight (kg/day)	Calcium (g/day)	Potassium (g/day)	Radionuclide intakes (picocuries/day)					
						Radium-226 [a]	Strontium-89	Strontium-90	Cesium-137	Barium-140	Iodine-131
Ala., Montgomery	July	11–16	1.88	0.9	1.7	NA	10	24	95	0	0
	Aug	15–17	2.20	1.1	2.6	NA	5	26	90	0	0
	Sept	15–17	2.23	1.1	2.2	NA	5	20	110	0	0
Alaska, Palmer	July	10–16	1.60	1.0	2.4	0.6	10	38	160	0	0
	Aug	10–11	1.66	1.0	1.7	3.3	10	25	135	0	0
	Sept	11	1.63	0.5	1.8	1.1	5	26	165	0	0
Ark., Little Rock	July	7–12	1.69	0.7	2.0	NA	10	37	85	0	0
	Aug	8–12	1.68	0.8	1.8	NA	5	35	100	0	0
	Sept	10–12	1.67	1.2	1.7	NA	5	48	75	0	0
Calif., Los Angeles	July	NS	[a] NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Sept	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
Colo., Denver	July	10–17	2.50	1.2	3.5	1.8	5	40	225	0	0
	Aug	10–17	2.53	1.5	3.5	3.3	15	40	175	0	0
	Sept	10–17	2.21	1.1	3.3	2.4	5	15	110	0	0
Conn., Hartford	July	1–18	1.88	1.1	2.6	1.1	5	26	170	0	0
	Aug	1–15	1.76	1.1	3.0	1.1	5	21	175	0	0
	Sept	14–19	2.04	1.2	2.9	1.0	5	20	145	0	0
Del., Wilmington	July	11–13	1.87	1.3	2.4	0.4	5	24	130	0	0
	Aug	10–12	1.23	NA	1.7	0.7	5	17	85	0	0
	Sept	11–12	1.92	1.9	3.3	1.7	5	33	135	0	0
Fla., Tampa	July	7–17	1.73	1.0	1.7	[b] NA	5	21	200	0	0
	Aug	9–16	1.81	1.1	1.6	NA	5	20	215	0	0
	Sept	10–12	2.24	1.6	2.0	NA	5	29	325	0	0
Ga., Atlanta	July	7–16	1.50	0.8	1.6	NA	5	32	80	0	0
	Aug	6–17	1.82	0.7	2.0	NA	5	33	90	0	0
	Sept	5–15	1.74	0.9	2.1	NA	5	33	115	0	0
Hawaii, Honolulu	July	6–10	1.82	0.7	2.0	1.8	5	15	120	0	0
	Aug	15–19	1.66	0.8	2.0	0.8	5	17	110	0	0
	Sept	15–19	1.74	0.7	2.3	2.3	5	10	105	0	0
Idaho, Idaho Falls	July	15–17	2.12	1.5	3.4	1.1	5	47	265	0	0
	Aug	16–17	1.77	0.9	2.5	0.7	10	35	170	0	0
	Sept	14–17	2.07	1.2	3.5	0.4	5	50	250	0	0
Ill., Chicago	July	10–12	1.75	1.4	2.6	1.1	5	24	150	0	0
	Aug	11–12	1.70	1.2	2.6	1.2	5	26	130	0	0
	Sept	11–14	1.85	1.3	2.8	1.3	5	15	130	0	0
Ind., Indianapolis	July	4–11	1.35	1.1	1.9	0.9	5	20	80	0	0
	Aug	7–16	1.84	1.3	2.9	1.3	5	20	110	0	0
	Sept	15–16	1.87	1.7	2.8	1.5	5	26	110	0	0
Iowa, Des Moines	July	5–12	2.06	1.6	2.3	NA	10	47	115	0	0
	Aug	5–13	2.37	1.9	2.6	NA	5	45	140	0	0
	Sept	15–17	2.43	1.7	2.4	NA	5	44	145	0	0
Kansas, Wichita	July	13	1.88	1.1	1.9	NA	5	26	55	0	0
	Aug	10	1.86	1.1	2.4	NA	5	22	150	0	0
	Sept	12	1.92	1.3	2.5	NA	5	33	85	0	0
Ky., Louisville	July	15–18	2.26	0.9	2.0	NA	11	32	90	0	0
	Aug	15–16	2.50	2.0	3.0	NA	5	60	113	0	0
	Sept	15–17	1.98	1.4	2.2	NA	5	38	60	0	0
La., New Orleans	July	12	2.59	1.6	3.4	NA	25	80	210	0	0
	Aug	13–15	2.63	1.6	2.9	NA	5	68	170	0	0
	Sept	11–15	2.45	1.5	3.2	NA	5	51	145	0	0
Maine, Portland	July	10–16	2.18	1.3	3.3	0.9	5	46	325	0	0
	Aug	10–19	2.09	1.7	2.7	1.9	5	48	270	0	0
	Sept	15–17	2.39	1.7	3.6	1.9	5	36	225	0	0
Md., Baltimore	July	7–15	2.04	1.4	2.7	NA	5	43	165	0	0
	Aug	8–15	2.12	1.5	2.3	NA	5	38	115	0	0
	Sept	11–12	2.11	1.5	2.3	NA	5	38	95	0	0
Mass., Boston	July	9–11	1.71	1.4	2.4	0.9	5	31	265	0	0
	Aug	11–13	1.85	1.3	2.8	1.1	5	39	230	0	0
	Sept	10–13	1.06	0.6	1.6	0.7	5	15	115	0	0
Mich., Detroit	July	7–14	1.74	1.0	2.1	1.7	5	19	130	0	0
	Aug	9–15	1.96	1.6	3.1	1.4	5	25	175	0	0
	Sept	10–15	2.23	1.8	3.1	1.6	5	18	155	0	0
Minn., Minneapolis	July	2–8	1.98	1.0	2.6	1.2	5	34	150	0	0
	Aug	2–8	1.56	0.9	1.7	1.1	5	27	125	0	0
	Sept	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
Miss., Columbia	July	14–17	2.14	1.7	2.6	NA	30	73	225	0	0
	Aug	15–17	1.86	1.7	2.2	NA	5	50	160	0	0
	Sept	12–18	1.61	1.4	1.6	NA	5	45	105	0	0
Mo., St. Louis	July	8–15	2.58	1.8	3.6	2.3	15	46	130	0	0
	Aug	7–13	2.56	1.5	3.6	2.3	5	44	140	0	0
	Sept	13–18	1.86	0.9	2.0	1.4	5	11	100	0	0
Mont., Helena	July	7–17	1.87	0.9	2.2	1.3	5	26	150	0	0
	Aug	10–16	1.80	0.7	1.8	1.1	5	23	115	0	0
	Sept	17	1.97	0.6	2.2	1.2	5	28	150	0	0

TABLE 2.—INSTITUTIONAL DAILY DIETARY INTAKE, THIRD QUARTER 1964—Continued

Location of institution	1964	Age (years)	Total weight (kg/day)	Calcium (g/day)	Potassium (g/day)	Radionuclide intakes (picocuries/day)					
						Radium-226 [a]	Strontium-89	Strontium-90	Cesium-137	Barium 140	Iodine-131
Nebr., Omaha	July	10–14	2.39	2.2	3.8	0.5	10	53	180	0	0
	Aug	10–17	1.84	1.5	2.2	1.1	10	33	90	0	0
	Sept	15–17	1.91	1.1	2.1	2.1	5	40	85	0	0
Nev., Carson City	July	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Sept	15–17	2.41	1.2	3.6	0.5	5	55	120	0	0
N. J., Trenton	July	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	16	2.26	0.9	2.9	3.4	5	36	125	0	0
	Sept	15	2.44	1.2	2.9	2.4	5	22	120	0	0
N. Mex., Albuquerque	July	5–11	1.74	1.6	2.4	1.6	5	24	85	0	0
	Aug	5–11	1.83	0.5	2.9	1.1	5	7	90	0	0
	Sept	5–11	2.08	1.0	2.9	1.0	5	17	85	0	0
N. Y., New York	July	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Sept	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
N. C., Charlotte	July	8–17	1.73	0.9	1.6	NA	5	33	80	0	0
	Aug	7–14	1.88	1.1	1.9	NA	5	49	95	0	0
	Sept	16–17	1.59	1.1	1.7	NA	5	45	72	0	0
N. D., Fargo	July	9–16	1.70	1.5	2.4	0.2	5	26	185	0	0
	Aug	10–16	1.06	1.3	1.5	2.1	5	19	90	0	0
	Sept	10–12	1.44	0.9	2.3	0.9	5	23	115	0	0
Ohio, Cleveland	July	6–12	2.01	1.4	3.0	0.8	5	28	160	0	0
	Aug	6–12	1.82	1.1	3.3	1.3	5	22	145	0	0
	Sept	10–12	1.67	1.2	2.5	1.2	5	20	115	0	0
Okla., Oklahoma City	July	15–19	1.76	0.7	1.4	NA	5	14	60	0	
	Aug	12–14	2.22	0.9	1.8	NA	5	18	45	0	0
	Sept	11–14	1.41	0.8	1.1	NA	5	21	63	0	0
Ore., Portland	July	14–17	2.25	1.1	2.5	0.7	5	29	125	0	0
	Aug	13–16	2.03	0.6	2.0	1.0	5	24	110	0	0
	Sept	13–17	1.85	0.6	2.6	0.9	5	37	130	0	0
Pa., Pittsburgh	July	14	2.26	1.4	3.2	1.1	5	38	190	0	0
	Aug	14	2.33	1.4	3.3	1.9	5	37	185	0	0
	Sept	15–16	2.06	1.2	2.9	1.4	5	29	135	0	0
S. C., Charleston	July	14	1.70	0.7	1.9	NA	5	27	95	0	0
	Aug	8	1.67	0.8	1.8	NA	5	20	100	0	0
	Sept	10–14	1.92	1.2	2.1	NA	5	42	145	0	0
Tenn., Memphis	July	14–17	1.48	1.0	1.9	NA	5	34	60	0	0
	Aug	14–17	1.64	1.0	1.6	NA	5	48	65	0	0
	Sept	14–17	1.64	1.0	1.6	NA	5	33	65	0	0
Texas, Austin	July	13–19	2.12	1.1	2.1	NA	5	21	75	0	0
	Aug	15–17	1.90	1.0	1.7	NA	5	30	50	0	0
	Sept	13–15	1.97	1.0	1.8	NA	5	22	70	0	0
Utah, Salt Lake City	July	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Sept	16	1.85	0.9	2.8	1.1	5	39	150	0	0
Vt., Burlington	July	6–16	1.47	1.5	2.2	1.3	5	29	155	0	0
	Aug	7–12	1.68	0.8	2.7	0.7	5	32	160	0	0
	Sept	10–12	1.55	0.8	2.5	2.8	5	19	130	0	0
Va., Norfolk	July	11–17	2.10	1.0	2.5	NA	10	38	125	0	0
	Aug	11–15	2.27	1.1	2.3	NA	5	36	115	0	0
	Sept	15–17	2.46	1.2	2.2	NA	5	32	135	0	0
Wash., Seattle	July	15–17	2.46	1.7	3.7	1.5	5	64	345	0	0
	Aug	15–17	2.36	1.7	2.8	2.6	5	52	285	0	0
	Sept	17	2.07	0.8	3.5	1.7	5	23	250	0	0
Va., Charleston	July	10–12	1.80	1.1	2.2	NA	5	41	110	0	0
	Aug	10–12	2.08	1.0	2.1	NA	5	48	125	0	0
	Sept	10–12	2.03	1.0	1.8	NA	5	37	80	0	0
Wisc., Milwaukee	July	5–16	1.53	1.1	2.3	0.3	5	12	130	0	0
	Aug	15–17	2.67	1.6	3.7	1.9	5	35	200	0	0
	Sept	15–17	2.31	1.8	3.2	1.4	5	25	160	0	0
Wyo., Laramie	July	13–17	1.96	1.2	2.5	1.6	5	39	125	0	0
	Aug	11–14	1.90	1.1	2.5	2.1	5	42	115	0	0
	Sept	11	1.16	0.3	1.9	1.2	5	15	65	0	0
Institution Average	July		1.92	1.2	2.4	1.2	5	34	145	0	0
	Aug		1.95	1.2	2.4	1.6	5	33	135	0	0
	Sept		1.93	1.1	2.5	1.5	5	30	125	0	0

[a] Average for radium-226 does not include total radium.
[b] NS indicates no sample.
[c] NA indicates no analysis.

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Correction for March issue

Values for stable strontium are incorrectly reported in tables 2 and 3 of the article "Estimated Daily Intake of Radionuclides in California Diets," which appeared on page 154 of the March 1965 *RHD*. Table 1 is correct as given. The decimal point is misplaced in the right-hand column of both tables 2 and 3, making the stable strontium data appear too high; the decimal point should be moved one place to the left.

Section III—Water

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, OCTOBER 1964

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has been expanded to 131 stations as of March 1, 1965. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological, and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the system provides background information necessary for recognizing pollution and water quality trends and for determining current and general levels of radioactivity to which the population may be exposed. Data assembled through the system and exact locations of sampling points are published in annual compilations (*1-7*).

Sampling procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary.

Presently, gross alpha and beta determinations are made either on monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radiactive waste and for other selected stations to observe short term changes due to weapons testing or other nuclear activities. Weekly analyses are also conducted at all newly established stations for the first year of operation.

Strontium-90 analyses are performed on total solids of three-month composites of the weekly samples. The most recent strontium-90 results are presented in the March 1965 issue of *RHD*.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*8*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is performing properly, are used for daily checking of the counter.

Results

Table 1 presents October 1964 results of alpha and beta analysis of U. S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first stations listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the system's "Annual Compilation of Data" (*7*). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, OCTOBER 1964

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	3	13	16	0	2	2
Apalachicola River:						
Chattahoochee, Fla.	2	4	6	<1	0	<1
Arkansas River:						
Coolidge, Kansas	2	24	26	0	23	23
Ponca City, Okla.	30	34	64	0	2	2
Atchafalaya River:						
Morgan City, La.	22	18	40	6	2	8
Bear River:						
Preston, Idaho	1	15	16	0	4	4
Big Horn River:						
Hardin, Mont.	9	18	27	0	7	7
Big Soiux River:						
Sioux Falls, S. Dak.	2	24	26	0	0	0
Chattahoochee River:						
Atlanta, Ga.	6	7	13	1	0	1
Columbus, Ga.	6	6	12	1	0	1
Lanett, Ala.	9	7	16	2	0	2
Chena River:						
Fairbanks, Alaska	1	7	8	0	0	0
Clinch River:						
Clinton, Tenn.	3	12	15	1	2	3
Kingston, Tenn.	10	49	59	<1	<1	<1
Colorado River:						
Loma, Colo.	2	24	26	0	10	10
Page, Ariz.	0	24	24	0	4	4
Parker Dam, Calif-Ariz.	0	13	13	0	5	5
Columbia River:						
Wenatchee, Wash.	7	9	16	0	0	0
Pasco, Wash.	104	538	642	0	<1	<1
Clatskanie, Ore.	27	200	227	0	<1	<1
Connecticut River:						
Enfield Dam, Conn.	3	12	15	1	0	1
Coosa River:						
Rome, Ga.	20	5	25	5	0	5
Cumberland River:						
Cheatham Lock, Tenn.	0	11	11	0	0	0
Delaware River:						
Philadelphia, Pa.	1	8	9	0	0	0
Escambia River:						
Century, Fla.	4	8	12	<1	0	<1
Great Lakes:						
Duluth, Minn.	0	5	5	0	0	0
Hudson River:						
Poughkeepsie, N.Y.	2	28	30	0	0	0
Illinois River:						
Grafton, Ill.	4	15	19	1	2	3
Kansas River:						
De Soto, Kans.	13	36	49	2	2	4
Maumee River:						
Toledo, Ohio	8	18	26	1	2	3
Mississippi River:						
St. Paul, Minn.	6	26	32	0	0	0
Dubuque, Iowa	2	22	24	0	1	1
E. St. Louis, Ill.	3	18	21	2	1	3
Vicksburg, Miss.	12	27	39	3	1	4
New Roads, La.	15	18	33	2	2	4
New Orleans, La.	4	17	21	1	2	3
Missouri River:						
Williston, N. Dak.	7	21	28	1	5	6
Bismarck, N.Dak.	4	27	31	0	3	3
Yankton, S.Dak.	2	30	32	1	4	5
St. Joseph, Mo.	22	29	51	4	7	11
North Platte River:						
Henry, Nebr.	6	38	44	1	25	26
Ohio River:						
Cairo, Ill.	2	10	12	1	2	3
Toronto, Ohio	2	18	20	0	0	0
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	7	7	0	1	1
Platte River:						
Plattsmouth, Nebr.	20	18	38	5	4	9
Potomac River:						
Washington, D.C.	1	12	13	1	1	2
Red River, North:						
Grand Forks, N. Dak.	5	32	37	0	2	2
Red River, South:						
Alexandria, La.	28	11	39	4	1	5
Rio Grande:						
El Paso, Tex.	8	54	62	2	10	12
Laredo, Tex.	48	20	68	9	4	13
Sacramento River:						
Greens Landing, Calif.	1	6	7	0	1	1
San Joaquin River:						
Vernalis, Calif.	9	16	25	2	12	14
San Juan River:						
Shiprock, N. Mex.	12	19	31	2	9	11
Savannah River:						
Port Wentworth, Ga.	4	13	17	<1	0	<1
Snake River:						
Wawawai, Wash.	4	11	15	0	3	3
South Platte River:						
Julesburg, Colo.	8	62	70	1	28	29
Tennessee River:						
Lenoir City, Tenn.	2	6	8	1	0	1
Chattanooga, Tenn.	2	10	12	0	0	0
Bridgeport, Ala.	4	10	14	0	1	1
Pickwick Landing, Tenn.	3	10	13	<1	<1	<1
Tombigbee River:						
Columbus, Miss.	4	6	10	<1	0	<1
Wabash River:						
New Harmony, Ind.	2	12	14	0	1	1
Yellowstone River:						
Sidney, Mont.	3	18	21	0	7	7
Maximum	104	538	642	9	28	29
Minimum	0	4	5	0	0	0

FIGURE 1. SAMPLING LOCATIONS AND ASSOCIATED TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, OCTOBER 1964

samples have zero pc/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5 the mean is reported as<1 pc/liter.

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations as shown in figure 1 which gives the October 1964 average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. Gross radioactivity results for the years 1957-1962 have been summarized by Weaver *et al* (*9*).

Discussion

The monthly dissolved beta activity averages exceeded 100 pc/liter at two stations on the Columbia River; Pasco, Washington, and Clatskanie, Oregon.

Dissolved alpha activity, associated with the dissolving of natural surface minerals by water, ranged from 0 to 28 pc/liter. Of all stations, 4 stations on different rivers had monthly average dissolved alpha activity greater than 10 pc/liter.

The radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*10*). The Public Health Service Drinking Water Standards state that in the absence of strontium-90 and alpha emitters, [1] a water supply is acceptable when the gross beta concentration does not exceed 1,000 pc/liter (*11*).

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(*8*) AMERICAN PUBLIC HEALTH ASSOCIATION; AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater. 11th Edition, New York (1960).
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(*10*) STRAUB, C. P. Significance of radioactivity data, J. Amer. Water Works Assoc. 53; 704 (June 1961).
(*11*) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962. Public Health Service Publication No. 956, Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402 (March 1963), Price 30 cents.

[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium-90 respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U. S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

Corrections for March Issue

In figure 1 on page 156, the date in title is incorrect and should read, "SAMPLING LOCATIONS and ASSOCIATED TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, SEPTEMBER 1964"; the date of June 1964 in column 1 of text referring to figure 1 should be changed to September 1964.

The column of figures on right hand side of table 1, "Radioactivity in Raw Surface Waters, September 1964" on page 157 contains misaligned values. The corrected table appears below.

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, SEPTEMBER 1964

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved		Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	4	14	18	1	1	2
Apalachicola River:						
Chattahoochee, Fla.	2	2	4	0	0	0
Arkansas River:						
Coolidge, Kansas	6	43	49	0	12	12
Ponca City, Okla.	53	31	84	9	0	9
Atchafalaya River:						
Morgan City, La.	7	16	23	0	1	1
Bear River:						
Preston, Idaho	0	8	8	0	2	2
Big Horn River:						
Hardin, Mont.	7	9	16	1	10	11
Chattahoochee River:						
Atlanta, Ga.	5	9	14	<1	0	<1
Columbus, Ga.	2	7	9	0	0	0
Lanett, Ala.	2	4	6	0	0	0
Chena River:						
Fairbanks, Alaska	1	8	9	0	1	1
Clinch River:						
Clinton, Tenn.	0	7	7	0	0	0
Kingston, Tenn.	12	23	35	0	0	0
Colorado River:						
Loma, Colo.	4	0	4	1	17	18
Page, Ariz.	1	34	35	0	5	5
Parker Dam, Calif-Ariz.	1	19	20	0	10	10
Columbia River:						
Wenatchee, Wash.	0	11	11	0	0	0
Pasco, Wash.	123	981	1104	0	1	1
Clatskanie, Ore.	18	150	168	<1	<1	<1
Connecticut River:						
Enfield Dam, Conn.	0	9	9	0	0	0
Cumberland River:						
Cheatham Lock, Tenn.	0	8	8	0	0	0
Delaware River:						
Philadelphia, Pa.	1	7	8	0	0	0
Escambia River:						
Century, Fla.	5	8	13	1	0	1
Great Lakes:						
Duluth, Minn.	0	1	1	0	0	0
Hudson River:						
Poughkeepsie, N.Y.	4	13	17	0	0	0
Illinois River:						
Grafton, Ill.	6	17	23	1	2	3
Kansas River:						
De Soto, Kans.	51	33	84	7	1	8
Maumee River:						
Toledo, Ohio	4	18	22	1	1	2
Mississippi River:						
St. Paul, Minn.	1	27	28	0	2	2
E. St. Louis, Ill.	8	19	27	1	2	3
Vicksburg, Miss.	13	22	35	2	1	3
New Roads, La.	11	19	30	1	1	2
New Orleans, La.	0	16	16	0	1	1
Missouri River:						
Williston, N. Dak.	5	22	27	0	4	4
St. Joseph, Mo.	34	31	65	10	4	14
North Platte River:						
Henry, Nebr.	3	34	37	0	21	21
Ohio River:						
Cairo, Ill.	0	6	6	0	1	1
Toronto, Ohio	2	16	18	0	0	0
Platte River:						
Plattsmouth, Nebr.	58	22	80	12	3	15
Potomac River:						
Washington, D.C.	2	11	13	0	0	0
Red River, North:						
Grand Forks, N. Dak.	2	30	32	0	1	1
Red River, South:						
Alexandria, La.	13	20	33	2	1	3
Rio Grande:						
El Paso, Tex.	96	29	125	25	0	25
Laredo, Tex.	418	16	434	73	1	74
San Joaquin River:						
Vernalis, Calif.	6	24	30	1	7	8
San Juan River:						
Shiprock, N. Mex.	855	26	881	264	6	270
Savannah River:						
Port Wentworth, Ga.	5	13	18	0	0	0
Snake River:						
Wawawai, Wash.	3	11	14	0	2	2
South Platte River:						
Julesburg, Colo.	3	51	54	0	18	18
Susquehanna River:						
Conowingo, Md.	2	9	11	0	0	0
Tennessee River:						
Lenoir City, Tenn.	1	7	8	0	0	0
Chattanooga, Tenn.	2	10	12	0	<1	<1
Bridgeport, Ala.	0	14	14	1	0	1
Pickwick Landing, Tenn.	2	11	13	0	<1	<1
Tombigbee River:						
Columbus, Miss.	3	8	11	0	0	0
Wabash River:						
New Harmony, Ind.	8	13	21	0	<1	<1
Yellowstone River:						
Sidney, Mont.	25	18	43	3	3	6
Maximum	855	981	1104	264	21	270
Minimum	0	0	1	0	0	0

Note: These data are preliminary: reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the system's annual report.

Section IV—Other Data

CESIUM-137 BURDENS IN MAN, JULY 1963 THROUGH AUGUST 1964[1]

Frank C. Leitnaker, Richard C. Reba, and *Kent T. Woodward* [2]

Whole body cesium-137 burdens have been determined periodically by liquid-scintillation whole-body counting at the Walter Reed Army Institute of Research (WRAIR) since 1957 (*1, 2*). This paper concerns the data obtained from July 1963 through August 1964.

Procedure

During this period 690 assays of 628 subjects were done, with each determination based on a 200-second counting time. Subjects were primarily active duty military personnel (general population). Those subjects having radioisotope contact were carefully noted. Cesium-137 body burdens are expressed as "picocuries cesium-137 per gram potassium" (pc Cs^{137}/g K). The precision of the measurement is illustrated by 14 separate determinations on the same subject over an eight-month period. With a mean body burden of 13.0 nc or 78.21 pc/g K, the standard deviation was 4.5 percent with a standard error of 1.2 percent. Thus, the 95 percent confidence limits for the precision of any individual cesium-137 burden determined in the routine manner should be about ±1.2 nc.

Results

Human burdens were found to be other than normally distributed (figure 1). The distribution of pc Cs^{137}/g K for all subjects counted in July and August 1964, as well as for subjects counted over the entire period, approximates a log-normal distribution (straight line fit on log probability paper—figure 2). Ellett and Brownell (*3*) have found that their data (cesium-137/g muscle) best fit a gamma distribution. These data will be submitted to goodness of fit testing for normal, log normal, and gamma distributions. The skewness of the Walter Reed population distribution is not extreme and other workers have generally assumed similar distributions for the same kinds of data to be normal (*2, 4, 5*). The main error in this assumption has been in estimating expected numbers in the population which would exceed three times the mean values. Differences between the arithmetical and geometrical means of each population are small. Since no rigorous statistical analysis is presented at this time, the data are expressed in the usual statistical parameters of arithmetical mean and standard deviation.

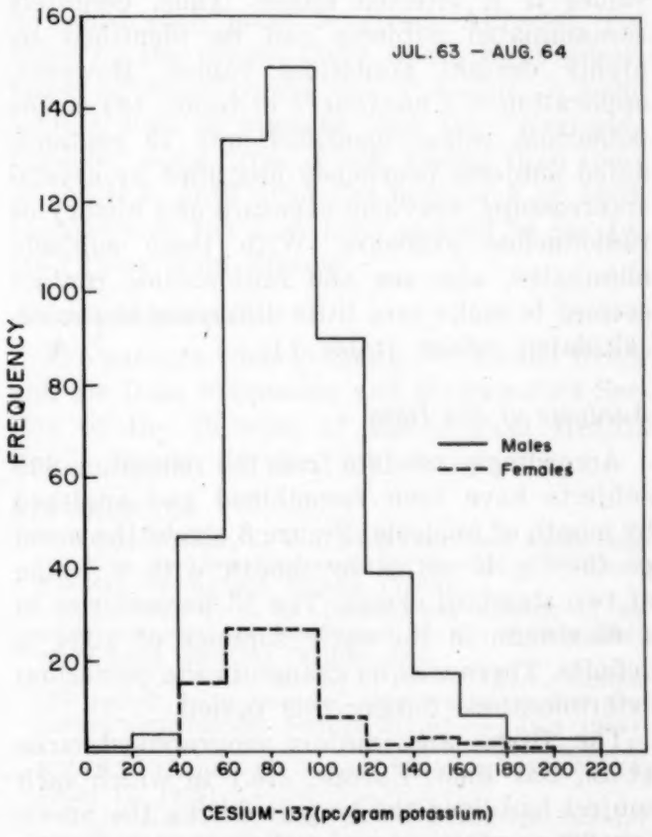

FIGURE 1. FREQUENCY DISTRIBUTION OF THE WALTER REED POPULATION

[1] This study was supported in part by Defense Atomic Support Agency contract RD 41-61, Subtask 03.083.

[2] Dr. Leitnaker is Research Fellow in Radiation Biology (Isotope Metabolism), Dr. Reba is Chief of the Department of Isotope Metabolism, and Dr. Woodward is Director of the Division of Nuclear Medicine, Walter Reed Army Institute of Research, Washington, D.C.

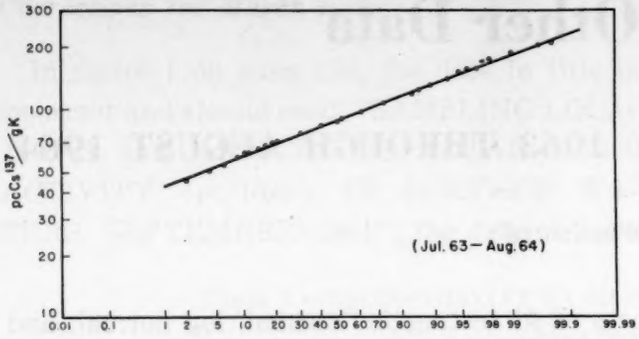

FIGURE 2. CUMULATIVE DISTRIBUTION OF CESIUM-137/POTASSIUM, U.S.A. AND EUROPE ADULT POPULATIONS, JULY 1963–AUGUST 1964

Total body potassium for each subject was also determined. Since the calculations assume no source of gamma radioactivity in the subject other than cesium-137 and potassium-40, contamination with other gamma emitters tends to produce erroneous results for one or both values. Depending on the energy of the contaminant, either or both values can be raised, or one raised and the other lowered. Actually, any contaminant (except ones which would exactly simulate either cesium-137 or potassium-40 in energy) would affect both values if it affected either. Thus, definitely contaminated subjects can be identified by highly deviant potassium values. However, application of Chauvenet's criterion (*6*) to the potassium values identified only 19 contaminated subjects previously identified by crystal spectroscopy, previous exposure and history of radionuclide exposure. With these subjects eliminated, age, sex and radionuclide contact seemed to make very little difference in the recalculated means (table 1).

Analysis of the Data

Accordingly, all data from the remaining 609 subjects have been recombined and analyzed by month of analysis. Figure 3 shows the mean pc Cs^{137}/g K ratios by month with a range of two standard errors. The 33 percent rise to a maximum in the early summer of 1964 is definite. There was no change in the potassium determinations during this period.

The State and major geographical area (U.S., Far East, Europe, *etc.*) in which each subject had lived the longest during the previous 30 months was recorded. Maryland, the District of Columbia, and Virginia represented 43 percent of all subjects reported. Cesium-137

TABLE 1.—CESIUM-137 LEVELS BY AGE, SEX AND RADIOLOGICAL EXPOSURE, JULY 1963–AUGUST 1964

Age range	Sex	Rad. exp.	Av. age	Number of subjects	Cs pc/g K	Standard error
0–9	F	−	6	8	80.33	7.08
10–19	M	−	16	19	89.90	5.56
		*+	19	2	167.17	39.40
	F	−	17	19	86.56	6.06
		+	19	2	74.34	9.38
20–29	M	−	24	144	92.83	2.65
		+	26	96	92.09	2.94
	F	−	23	28	75.29	3.46
		+	26	5	79.74	9.89
30–39	M	−	33	57	90.70	4.25
		+	34	105	93.36	2.38
	F	−	32	5	93.84	9.58
		+	35	7	88.84	7.05
40–49	M	−	44	18	97.84	10.05
		+	43	41	82.02	3.46
	F	−	45	11	82.53	10.90
		+	44	7	112.02	11.30
50–59	M	−	55	3	76.97	15.50
		+	54	10	92.01	6.27
	F	−	54	3	95.73	25.85
		+	53	3	73.01	7.59
60–69	M	+	62	3	81.29	11.91
	F	+	64	1	81.37	

* Plus sign indicates that subjects handled radioactive materials but were not contaminated.

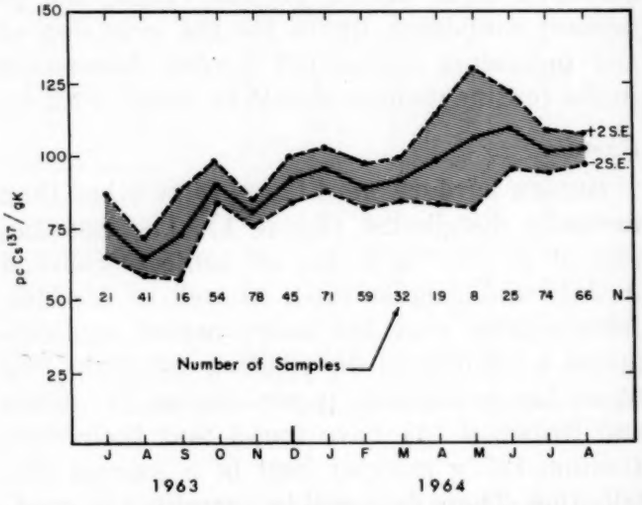

FIGURE 3. MEAN CESIUM-137 BURDENS IN WRAIR POPULATION SAMPLE FROM JULY 1963 TO AUGUST 1964

levels in those residing primarily in the U.S. during the last 30 months have been compared with those living in other areas (table 2). The data are, in general, too few for meaningful comparison except that the mean of cesium-137 of the group from Europe (primarily Ger-

many) appears to be about 30 percent higher than that of U.S. subjects. Different nationalities of people are not being compared, but groups of Americans living at home and abroad are. Although much of the American diet eaten by military personnel in Europe consists of food shipped from the United States, European sources provide most of the dairy products, meat, and fresh vegetables.

TABLE 2.—HUMAN BURDENS OF CESIUM-137 BY AREA OF RESIDENCE, JULY 1963–AUGUST 1964

Area	Number of subjects	Cesium-137 (pc/g K) mean & one St'd error
Far East	34	78.16±4.89
Near East	1	62.41
Asia	2	82.34±3.25
Europe	66	114.49±4.90
Africa	1	53.78
Caribbean	3	73.38±8.90
Central America	1	91.60
U.S.A.	499	88.97±1.62

An attempt to reveal time variations in cesium-137 levels by State was not feasible. To define real differences would require much larger sample sizes. To help achieve this, and in the hope that some combination would be more meaningful, the U.S. was divided into six arbitrary areas (figure 4). To increase the sample size further, combination into three areas was made when it was noted that each group had a mean pc Cs^{137}/g K value almost identical with an adjacent group. Mean values by month for paired areas also tended to rise and fall together.

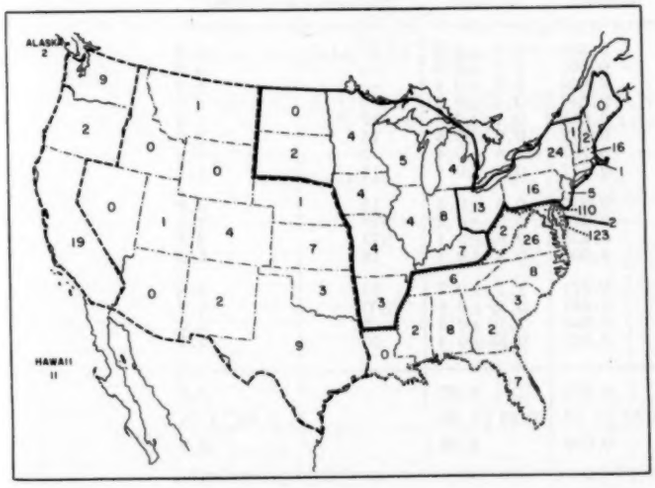

FIGURE 4. U.S. SUBJECTS COUNTED BY STATE

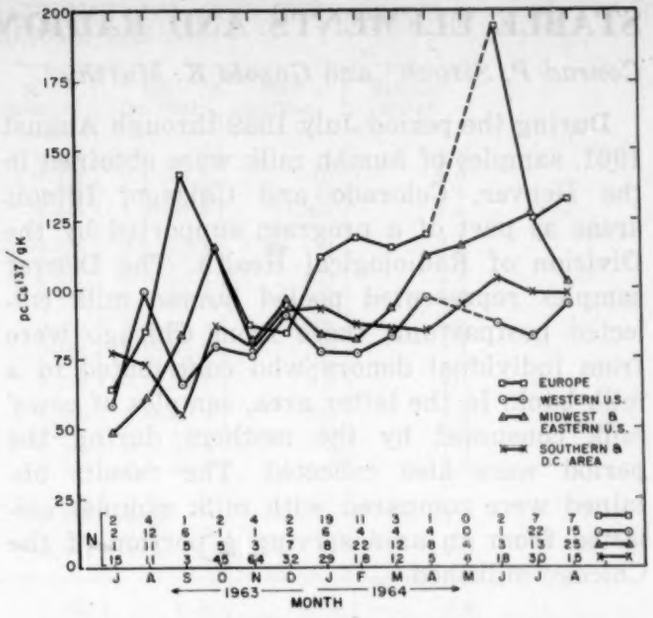

FIGURE 5. MONTHLY MEAN CESIUM–137 BURDENS BY AREA

Although these combined areas may not really be homogeneous, the data suggest that there is not much difference between them. Figure 5 compares the mean monthly cesium-137 levels of the three large U.S. areas with those from Europe. The number of subjects, N, which determined each point is given. Although not noted on the graph, there was a large uncertainty of many points, due, it is felt, to small sample size. It appears that the "European burdens" were little, if any, higher than those in the U.S. until after the beginning of 1964. Increases in the U.S. level seemed to lag behind those from Europe.

Acknowledgments

The authors wish to thank Dr. Daniel Bruce and the Data Processing and Mathematics Section of the Division of Radiological Health, Public Health Service, for assistance.

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STABLE ELEMENTS AND RADIONUCLIDES IN HUMAN MILK

Conrad P. Straub [1] and *Gopala K. Murthy* [2]

During the period July 1959 through August 1961, samples of human milk were obtained in the Denver, Colorado and Chicago, Illinois areas as part of a program supported by the Division of Radiological Health. The Denver samples represented pooled human milk collected postpartum; those from Chicago were from individual donors who contributed to a milk bank. In the latter area, samples of cows' milk consumed by the mothers during the period were also collected. The results obtained were compared with milk samples collected from an area serving a portion of the Chicago milkshed.

The individual values are presented in tables 1 through 4. Table 1 lists the results obtained with the Denver human milk samples; table 2, the Chicago human milk samples; table 3, the Chicago cows' milk samples consumed by the donors; and table 4, the Chicago raw milkshed samples.

All data shown are expressed as the geometric mean and standard deviation ($M_g \times^{\div} \sigma_g$), the arithmetic mean ($\overline{M}$), and the median values (M_d). The results show that the human milk values in Denver and Chicago had respective geometric mean values of $0.24 \times^{\div} 1.28$ and $0.21 \times^{\div} 1.26$ g calcium/liter, $0.62 \times^{\div} 1.16$ and $0.32 \times^{\div} 1.18$ g potassium/liter, $0.62 \times^{\div} 1.55$ and $0.56 \times^{\div} 1.56$ pc/liter of strontium-90, and $2.52 \times^{\div} 1.73$ and $2.73 \times^{\div} 1.82$ pc strontium-90/g calcium. In addition, values for cesium-137 are shown. With the exception of the potassium concentrations, there is excellent agreement in the values reported for the two areas. The potassium difference is believed to be due to the nature of the human milk collected. The Denver samples were pooled from postpartum donors, whereas the Chicago samples were received from individual donors whose milk was obtained during later lactation stages. The values cited above may be compared with values for cows' milk as given in tables 3 and 4.

In a paper submitted for publication elsewhere (*1*), the data listed are compared with concentrations found in human milk by other authors.

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[2] Dr. Murthy is Research Chemist, Food Chemistry, Milk and Food Research Program, Division of Environmental Engineering and Food Protection, Robert A. Taft Sanitary Engineering Center, Public Health Service, U.S. Department of Health, Education, and Welfare, Cincinnati, Ohio.

REFERENCE

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TABLE 1.—CALCIUM, POTASSIUM, AND RADIONUCLIDE CONCENTRATIONS IN HUMAN MILK, DENVER, COLORADO

Sample number	Date	Ca (g/liter)	K (g/liter)	Sr^{90} (pc/liter)	Cs^{137} (pc/liter)	Sr^{90}/Ca (pc/g)
1	7/9/59	0.185	0.552	[a] 0.7 ±0.6	[a, b] 11 ±1.3	3.8
2	7/17/59	0.220	0.561	0.7 ±0.6	[c] —	3.2
3	11/5/59	0.212	0.664	0.2 ±0.4	—	0.9
4	11/16/59	0.227	0.643	0.4 ±0.6	19	1.8
5	11/27/59	0.293	0.618	0.4 ±0.6	17	1.4
6	12/16/59	0.277	0.712	0.6 ±0.4	15	2.2
7	1/8/60	0.277	0.707	0.5 ±0.4	5	1.8
8	1/18/60	0.358	0.777	0.6 ±0.4	15	1.7
9	1/19/60	0.183	0.630	0.6 ±0.4	15	3.2
10	3/14/60	0.252	0.674	0.7 ±0.4	[d] ND	2.8
11	3/16/60	0.218	0.658	0.8 ±0.4	ND	3.7
12	5/6/60	0.198	0.508	0.8 ±0.4	18	4.0
13	8/1/60	0.126	0.271	1.2 ±0.7	10	9.5
14	10/17/60	0.268	0.681	0.49 ±0.6	ND	1.8
15	12/60	0.275	0.563	1.10 ±0.3	5	4.0
16	2/61	0.228	0.567	0.84 ±0.4	10	3.7
Arith. average, $\overline{M}$		0.237	0.611	0.67		3.1
Geom. average, $M_g \times^{\div} \sigma_g$		$0.24 \times^{\div} 1.28$	$0.62 \times^{\div} 1.16$	$0.62 \times^{\div} 1.55$		$2.52 \times^{\div} 1.73$
Median, M_d		0.228	0.636	0.65		3.0

[a] Two σ counting error.
[b] By radiochemistry.
[c] —, no value available.
[d] ND indicates not detectable.

TABLE 2.—CALCIUM, POTASSIUM, AND RADIONUCLIDE CONCENTRATIONS IN HUMAN MILK, CHICAGO, ILLINOIS

Sample number	Date [a]	Ca (g/liter)	K (g/liter)	Sr^{90} (pc/liter)	Cs^{137} (pc/liter)	Sr^{90}/Ca (pc/g)
1	12/21/59	0.293	0.508	[b] 0.6 ±0.4	5	2.0
2	12/29/59	0.198	0.329	0.4 ±0.2	10	3.0
3	1/25/60	0.191	0.534	0.3 ±0.2	10	1.6
4	5/19/60	0.190	0.344	1.4 ±0.8	[c] ND	7.4
5	6/13/60	0.231	0.251	0.6 ±0.4	10	2.6
6	(6/60) 7/12/60	0.191	0.306	0.74±0.6	10	3.9
7	(7/60) 8/5/60	0.126	0.271	0.70±0.4	ND	5.6
8	(8/60) 9/12/60	0.162	0.290	0.95±0.4	ND	5.8
9	(9/60) 10/11/60	0.219	0.334	0.50±0.3	ND	2.3
10	(10/60)	0.215	0.269	0.66±0.6	10	3.1
11	(11/60)	0.301	0.307	0.66±0.4	ND	2.2
12	(12/60)	0.192	0.258	0.78±0.1	ND	4.1
13	(1/61)	0.178	0.339	0.88±0.2	ND	4.9
14	(2/61)	0.216	0.379	0.5 ±0.4	10	2.3
15	(3/61)	0.282	0.340	0.3 ±0.4	5	1.1
16	(4/61)	0.245	0.346	0.5 ±0.4	5	2.0
17	(5/61)	[d] —	—	0.67	—	—
18	(6/61)	0.228	0.312	0.42	—	1.8
19	(7/61)	—	—	0.25	—	—
20	(8/61)	0.205	0.340	0.32	—	1.6
Arith average, $\overline{M}$		0.215	0.336	0.61	4	3.2
Geom average, $M_g \times/\div \sigma_g$		$0.21 \times/\div 1.26$	$0.32 \times/\div 1.18$	$0.56 \times/\div 1.56$		$2.73 \times/\div 1.82$
Median, M_d		0.211	0.332	0.6		2.4

[a] Dates in parentheses indicate month of collection; other dates indicate when samples were received.
[b] Two-sigma counting error.
[c] ND indicates not detectable.
[d] Dashes indicate no values available.

TABLE 3.—CALCIUM, POTASSIUM, AND RADIONUCLIDE CONCENTRATIONS IN COWS' MILK, CONSUMED BY TEST SUBJECTS, CHICAGO, ILLINOIS

Sample number	Date [a]	Ca (g/liter)	K (g/liter)	Sr-90 [b] (pc/liter)	Cs-137 (pc/liter)	Sr-90/Ca (pc/g)	Observed ratio [c]
1	(11/60)	1.112	1.464	6.9±1.6	10	6.2	0.35
2	(12/60)	1.127	1.432	6.6±1.4	5	5.9	0.70
3	(1/61)	1.172	1.452	6.5±2.4	25	5.5	0.89
4	(2/61)	1.125	1.441	10.0±1.8	5	8.9	0.26
5	(3/61)	1.096	1.415	6.6±1.2	20	6.0	0.18
6	(4/61)	1.135	1.393	7.6±1.6	25	6.7	0.30
7	(5/61)	[d] —	—	5.6	—		
8	(6/61)	1.056	1.376	5.9	—	5.6	0.32
9	(7/61)	—	—	5.0	—		
10	(8/61)	1.068	1.394	4.4	—	4.1	0.39
Arith average, $\overline{M}$		1.111	1.421	6.5		6.1	0.42
Geom average, $M_g \times/\div \sigma_g$		$1.12 \times/\div 1.05$	$1.42 \times/\div 1.03$	$6.35 \times/\div 1.22$	$13 \times/\div 2.7$	$6.05 \times/\div 1.15$	$0.39 \times/\div 2.0$
Median, M_d		1.118	1.424	6.6	15	6.0	0.37

[a] Dates in parentheses are months of collection; other dates indicate when samples were received.
[b] Two-sigma counting error.
[c] Observed ratio $= \frac{(Sr^{90}/Ca)_h}{(Sr^{90}/Ca)_c}$; i.e., human milk to cows' milk.
[d] Dash indicates no value available.

TABLE 4.—CALCIUM, POTASSIUM, AND RADIONUCLIDE CONCENTRATIONS IN COWS' MILK, CHICAGO RAW MILKSHED SAMPLES

Sample number	Date	Ca (g/liter)	K (g/liter)	Sr-90 (pc/liter)	Cs-137 (pc/liter)	Sr-90/Ca (pc/g)
1	11/60	1.19	1.44	7.7±0.5	15	6.5
2	12/60	1.10	1.42	8.1±0.8	15	7.4
3	1/61	1.16	1.45	3.5±0.4	15	3.0
4	2/61	1.20	1.52	5.7±0.6	20	4.8
5	3/61	1.15	1.54	8.4±0.6	20	7.3
6	4/61	1.14	1.42	9.0±0.7	15	7.9
7	5/61	1.13	1.43	7.5±0.5	25	6.6
8	6/61	1.11	1.45	5.0±0.6	25	4.5
9	7/61	1.10	1.41	4.8±0.6	10	4.4
10	8/61	1.12	1.48	6.8±1.1	10	6.1
Arith average, $\overline{M}$		1.14	1.46	6.6	17	5.8
Geom average, $M_g \times/\div \sigma_g$		$1.13 \times/\div 1.04$	$1.44 \times/\div 1.02$	$6.6 \times/\div 1.48$	$16 \times/\div 1.53$	$5.8 \times/\div 1.37$
Median, M_d		1.14	1.44	7.2	15	6.3

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

Atomic Energy Commission contractors who handle or produce radioactive materials are required to report periodically to the Commission on the environmental levels of radioactivity in the vicinity of major installations. These reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity reports for selected AEC installations are regularly published in *Radiological Health Data*. Summaries appearing in this issue cover the monitoring programs during the first half of 1964 at the following installations: Bettis Atomic Power Laboratory, Knolls Atomic Power Laboratory, Feed Materials Production Center, and the S1C Prototype Reactor Facility.

Releases of radioactive materials from these installations for the periods covered in the reports below are governed by standards set fourth in appropriate chapters of the AEC manual. The radioactivity concentration limits applicable to effluents released from AEC installations are identical to those published in the Federal Register (*1*).

1. Bettis Atomic Power Laboratory[1] January–June 1964

Westinghouse Electric Corporation
Pittsburgh, Pennsylvania

The Bettis Atomic Power Laboratory (BAPL) operated for the Atomic Energy Commission by Westinghouse Electric Corporation, was established in 1949 to conduct research and development operations related to naval atomic propulsion systems and the central station atomic power reactor at Shippingport, Pennsylvania.

[1] Data and information summarized from reports to the Pennsylvania Department of Health entitled *Environmental Radioactivity at the Bettis Atomic Power Laboratory PNRO–DEV–130*. The reports were prepared by BAPL's Industrial Hygiene Department and transmitted through the AEC Pittsburgh Naval Radiation Office (July 20, 1964).

Routine environmental monitoring data from the sampling locations shown in figure 1 indicate that environmental radiation concentrations resulting from laboratory operations are well within Atomic Energy Commission prescribed limits (*1*).

Liquid radioactive waste

Liquid effluent discharged from the Laboratory is sampled continuously, and composite samples are analyzed weekly for gross alpha and gross beta-gamma activity and quarterly for strontium-90 activity. In addition, analysis for total uranium alpha activity is performed whenever the combined gross alpha activity exceeds 2,000 pc/liter.

The average concentration of gross radioactivity, including fallout, in the liquid effluent during the first six months of 1964 was 53 pc/liter. This represents a decrease from the 130 pc/liter average concentration observed in the first half of 1963. The average concentration of strontium-90 for the fourth quarter of 1963 was 4.0 pc/liter. The average concentration of strontium-90 for the first quarter of 1964 was 5.4 pc/liter.

The strontium-90 analyses for the second quarter 1964 have not been completed.

Background monitoring stations

Four background monitoring stations are in continuous operation on the Laboratory property. Three of the stations are located at the perimeter of the Laboratory and one station is centrally located with respect to the main Laboratory area. These stations continually measure and record the external beta-gamma radiation level, the external gamma radiation level and the beta-gamma activity of particulates in air as collected by a continuous air monitor of the moving filter type. Air samples are continuously collected at two of the stations. The filters removed from the high volume air samplers are retained for specific analysis when required to identify the nature of the airborne activity. External gamma activity for the three perimeter stations is given in table 1.

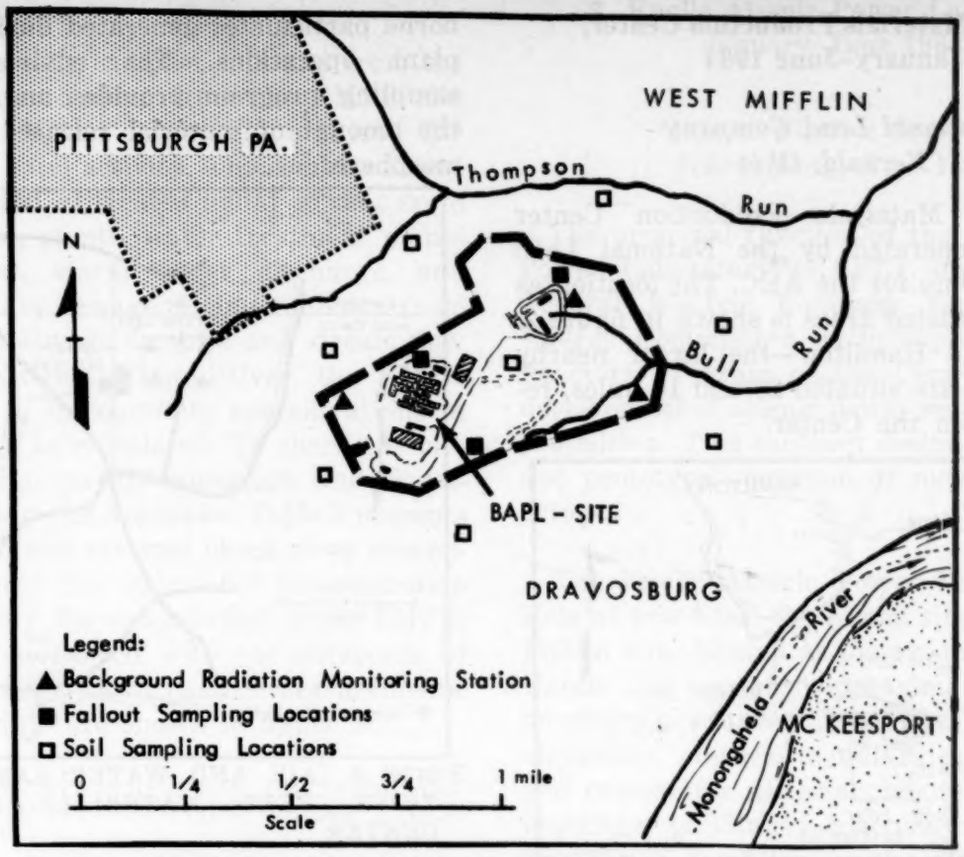

FIGURE 1. BETTIS ATOMIC POWER LABORATORY SAMPLING STATIONS

TABLE 1.—RADIOACTIVITY IN THE BAPL ENVIRONMENT, JANUARY–JUNE 1964

Type of measurement	First quarter	Second quarter
Liquid wastes (pc/liter)		
Gross activity [a]	[b] —	53
Strontium-90	5.4	[c] —
Beta-gamma dose rate (mrad/hr)	[b] —	0.016
Beta activity in fallout (mc/mi²/mo)	[b] —	[c, d] 15.7
Stream silt (pc/gram)		
Alpha: Station A	33	19
Station B	31	20
Station C	26	18
Beta: Station A	46	18
Station B	25	29
Station C	27	37

[a] An environmental MPC of 2000 pc/liter is used as the standard for liquid wastes effluent.
[b] Semi-annual average.
[c] Second quarter results not complete.
[d] Five months (through May) average for all stations.

Background beta-gamma radiation intensities averaged 0.016 mr/hr during this period. This is not significantly different from the background radiation intensities measured previously at the same location.

Stream silt

Stream silt sampling previously reported has now been discontinued.

Soil samples

Soil samples are collected at eight locations on and offsite and are retained for a period of two years. These samples are analyzed for radioactivity only on an "as required" basis. No analyses were required during the six-month period.

Fallout

Fallout samples, collected at three locations at the perimeter of the Laboratory over a period of one month in high-wall stainless steel pots, are analyzed for gross alpha activity and gross beta-gamma activity.

The average concentration of radioactive fallout for five months during the first half of 1964 was 15.7 mc/mi²/mo. (The analyses of samples for the month of June were incomplete at the time of reporting.) There was a decrease in fallout activity during this period as compared to the first six months of 1963.

Recent coverage in *Radiological Health Data:*

Period	*Issue*
July 1961 to June 1962	*April 1963*
July 1962 to June 1963	*April 1964*
July 1963 to December 1963	*November 1964*

2. Feed Materials Production Center, January–June 1964

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the AEC. The location as related to populated areas is shown in figure 2. Cincinnati and Hamilton—the larger nearby communities—are situated 20 and 10 miles, respectively, from the Center.

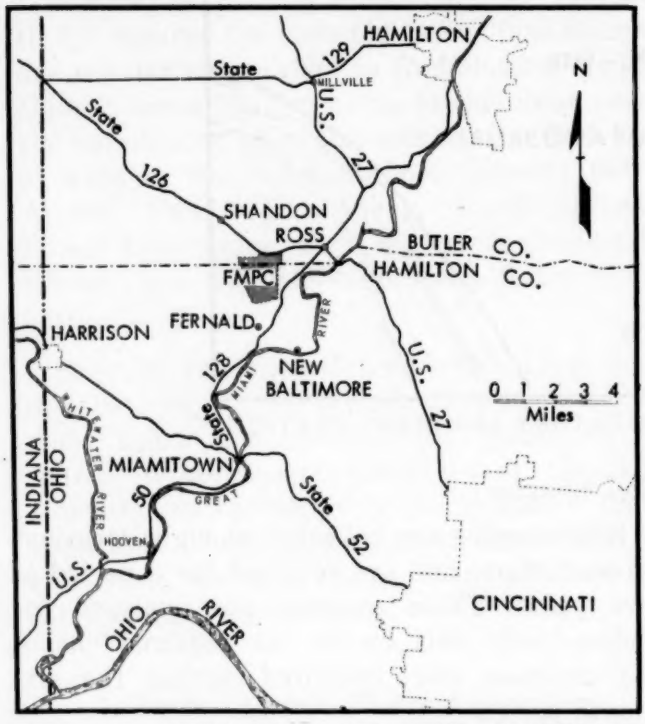

FIGURE 2. AREA MAP OF FEED MATERIALS PRODUCTION CENTER

Operations at this project deal with processing of high-grade uranium concentrates to produce metallic uranium and with fabricating the metal into fuel elements.

An environmental survey program of air and water sampling is maintained to check the effectiveness of dust collectors and waste treatment processes. Inspection of the data indicates that the release of radioactive materials to the environment is controlled as required by AEC and State of Ohio regulations.

Air monitoring

FMPC uses dust collectors such as bag collectors, electrostatic precipitators, and scrubbing towers which remove nearly all of the airborne particulates generated during the many plant operations. The environmental air sampling program provides an indication of the amount of material released into the atmosphere.

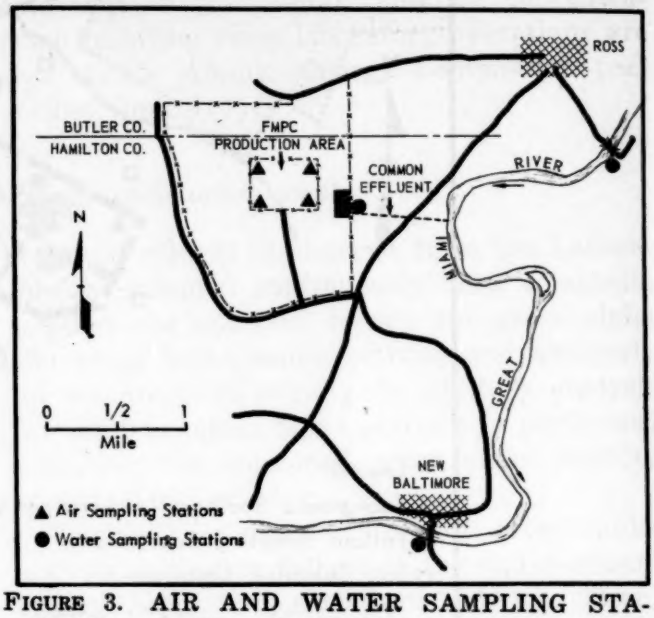

FIGURE 3. AIR AND WATER SAMPLING STATIONS, FEED MATERIALS PRODUCTION CENTER

Onsite samples were taken at four permanent sampling stations located at the four corners of the production area shown in figure 3. Offsite samples were taken by a mobile unit operated at various distances and directions from the plant determined by local meteorological conditions on the day of sampling. The data for the offsite samples are averaged in groups according to distance from the production area. Concentrations of uranium and total activity of airborne particulates sampled at onsite and offsite locations are given in table 2.

TABLE 2.—RADIOACTIVITY OF AIRBORNE PARTICULATES, FMPC

[Average concentrations in pc/m³]

Location	First half 1964		
	No. of samples	Uranium [a]	Total activity [b]
Onsite			
Southwest	25	0.2	1.3
Northwest	24	0.1	1.1
Northeast	25	0.3	1.6
Southeast	24	0.2	1.2
All onsite samples	98	0.2	1.3
Offsite			
0–2 miles from FMPC	34	0.2	1.4
2–4 miles from FMPC	24	0.1	1.0
4–8 miles from FMPC	38	0.1	1.3
8–10 miles from FMPC	10	0.1	1.1
All offsite samples	116	0.1	1.2

[a] MPC = 2 pc/m³
[b] MPC = 100 pc/m³

Water monitoring

Continuous daily samples, collected from the combined sewer leading from the FMPC site to the Great Miami River, are analyzed for uranium and total activity. The combined sewage is composed of treated liquid effluent from the production plants, water treatment plants waste effluent, storm sewer discharge, and treated sanitary sewage. Using the data from the combined sewage samples and stream flow data for the Great Miami River, the FMPC contribution to radioactivity concentrations in the river may be calculated. To check the calculated results, weekly upstream and downstream spot samples are taken. Table 3 presents the calculated and the spot check river concentrations. Since the calculated concentration represents only the contribution from FMPC, it should be compared with the difference of the upstream and downstream measurements. Sampling points are shown in figure 3.

TABLE 3.—CONCENTRATIONS OF URANIUM AND TOTAL ACTIVITY IN THE GREAT MIAMI RIVER, OHIO

[Average concentrations in pc/liter]

Location	Method of determination	First half 1964		
		No. of samples	Uranium [a]	Total activity [b]
Sewer outfall	Calculated from sewer concentrations and stream data (continuous sampling).	182	8	10
Upstream	Spot samples	26	7	30
Downstream	Spot samples	33	9	40
Difference		—	2	10

[a] MPC=20,000 pc/liter.
[b] MPC=3,000 pc/liter.

Recent coverage in *Radiological Health Data:*

Period	*Issue*
July–December 1960	*June 1961*
January–June 1961	*December 1961*
July 1961–June 1962	*March 1963*
July 1962–December 1963	*May 1964*

3. Knolls Atomic Power Laboratory January–June 1964

General Electric Company
Schenectady, New York

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission, is to support the Naval Reactors Program of the Commission in the development of atomic power reactors for naval propulsion. This includes design, construction, and prototype operation of nuclear power reactors.

The Knolls Atomic Power Laboratory consists of two sites, the Knolls site and the West Milton site, located as shown in figure 4. The Knolls site occupies approximately 170 acres on which are located administrative buildings; chemistry, physics, metallurgical, engineering, and radioactive materials laboratories; critical assembly buildings; machine shops; decontamination facilities; radioactive waste storage and processing facilities; and nuclear fuel storage and assembly buildings. The West Milton site occupies approximately 4,000 acres. Its principal facilities include the Triton (S3G) and Bainbridge (D1G) prototype reactors, equipment service building, fuel service building, and waste treatment facility. Regular environmental monitoring activities are conducted to assure that environmental radiation concentrations resulting from laboratory operations are well within Atomic Energy Commission prescribed limits (*1*).

Air Monitoring

Environmental airborne radioactivity is measured at two locations on the Knolls site, four locations at the West Milton site, and at the General Electric Company Research Laboratory, approximately one mile west of the Knolls site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis. The results of the airborne radioactivity analyses are given in table 4. Measurements of airborne radioactivity are made at least 48 hours after collection allowing the naturally occurring short-lived materials to decay.

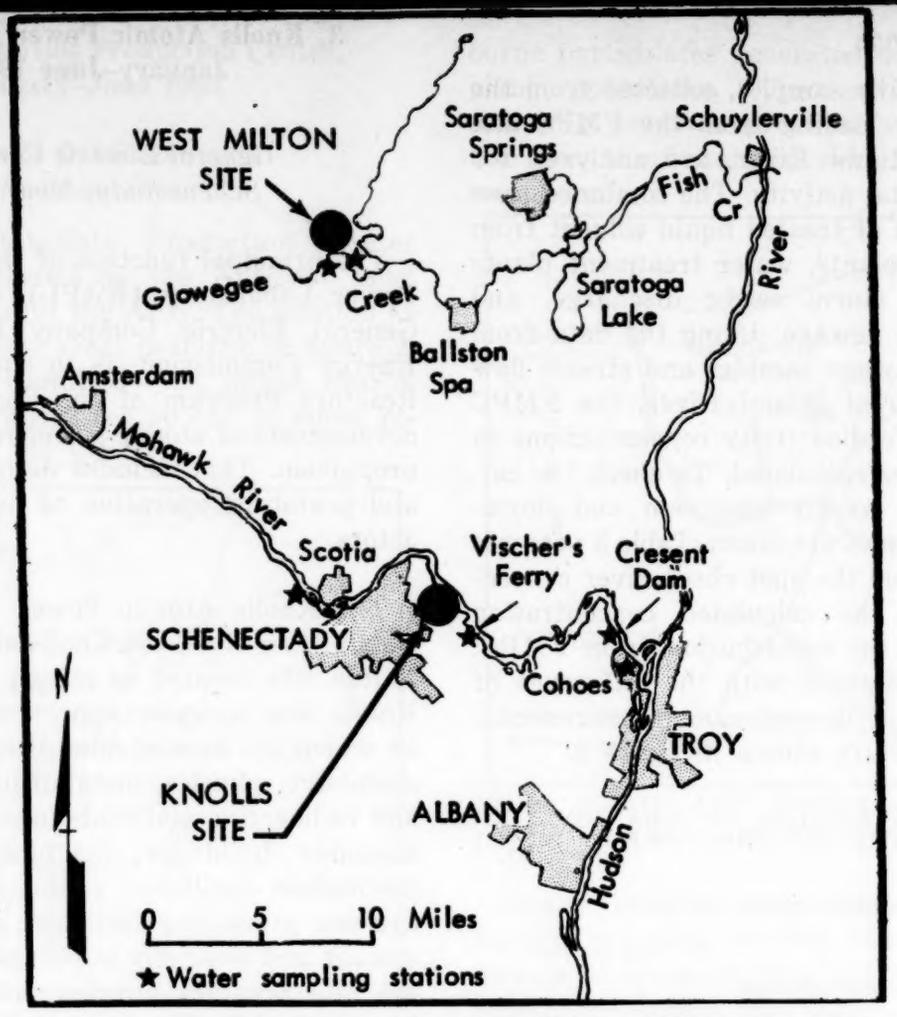

FIGURE 4. ENVIRONMENTAL MONITORING LOCATIONS, KAPL

TABLE 4.—AIRBORNE BETA ACTIVITY, KAPL, JANUARY–JUNE 1964

[Average concentrations in pc/m³]

Sampling locations	January–June 1964
Knolls site	1.41
West Milton site	1.45
Offsite	1.38

Liquid Waste Monitoring

The dilution potential of the Mohawk River is utilized to a limited degree in the disposal of liquid radioactive wastes from the Knolls site. All potential sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste processing building. The release of liquid waste to the Mohawk River is regulated according to (1) the concentration of fission products in the collection tanks, and (2) the flow of the river. A continuous proportional sample of the Knolls site combined sewer effluent is taken at the point of discharge to the Mohawk River. Radiochemical analyses of weekly composite samples show that strontium-90 is the principal component to be considered in control. The amounts and the radioisotopic content of the combined sewer effluent discharged from the Knolls site have been summarized in table 5. A total of 0.29 curie of beta activity was discharged to the Mohawk River during the 6-month period of this report.

TABLE 5.—RADIONUCLIDE CONCENTRATIONS IN THE KNOLLS SITE WASTE EFFLUENT, KAPL

[Average concentrations in pc/liter]

Radionuclides	January–June 1964
Sr-89	<11
Sr-90	370
Cs-137	500
Ce-144-Pr-144	200
Ru-106	<10
I-131	<11

Mohawk River water is sampled continuously at the point of discharge from the Knolls site; at the General Electric Company powerhouse eight miles upstream from the site; at the Vischer Ferry powerhouse approximately two miles downstream; and at the City of Cohoes pumping station about 13 miles downstream. Samples taken from the Cohoes station show very nearly the same average concentrations obtained for the Vischer Ferry samples (table 6).

TABLE 6.—GROSS BETA ACTIVITY IN STREAMS RECEIVING EFFLUENTS, KAPL

[Average concentration in pc/liter]

Stream and location	January–June 1964
Mohawk River (Knolls site): *	
G.E. Powerhouse (upstream)	10
Vischer Ferry (downstream)	11
Glowegee Creek (West Milton site): *	
Upstream	13
Downsteam	18

* MPCw = 100 pc/liter.

Since the Glowegee Creek does not have a reliable dilution potential, the radioactivity levels in the liquid waste from the West Milton site are operationally controlled and diluted prior to release to the creek. A total of 0.018 curie was discharged at two points into Glowegee Creek during the 6-month period at monthly average concentrations ranging from 7 to 80 pc/liter. Samples of the Glowegee Creek water are taken once a week at two locations, one at about 150 feet above the point where the S3G effluent enters the stream, and the other 2,640 feet below the S3G discharge or 1,500 feet below the D1G discharge.

Recent coverage in *Radiological Health Data:*

Period	*Issue*
Third and fourth quarters 1960	*September 1961*
First and second quarters 1961	*March 1962*
July 1961–June 1962	*July 1963*
July 1962–December 1963	*June 1964*

4. S1C Prototype Reactor Facility January–June 1964

Combustion Engineering, Inc.
Windsor, Connecticut

The S1C Prototype is a land-based nuclear submarine power plant facility, operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, at Windsor, Connecticut. The Prototype contains a pressurized water reactor power plant which is used for research, development, and training.

All materials released to the environment are routinely monitored to assure that waste disposal operations comply with AEC regulations. Monitoring results which follow indicate that the Facility has fully complied with the standards previously described (*1*).

Essentially all of the radioactive wastes originate from activation of minute amounts of impurities and corrosion products in the circulating water used as a reactor coolant. Ventilation air from the submarine hull and the supporting facility is continuously monitored at the exhaust stack. Liquid wastes are monitored before discharge to the Farmington River. Tables 7 and 8 give the average beta concentrations of airborne and liquid wastes before release to the environment.

TABLE 7.—AIRBORNE BETA ACTIVITY, S1C, JANUARY–JUNE 1964

[Average concentrations in pc/m³]

Sampling locations	Jan.–Mar. 1964	Apr.–June 1964
Stack discharge	48	48
Onsite average	1.2	1.1
Offsite average	8.2	1.1

TABLE 8.—RADIOACTIVITY IN LIQUID WASTES DISCHARGED INTO THE FARMINGTON RIVER, S1C, JANUARY–JUNE 1964

Activity	January–June 1964
Total beta activity (millicuries)	10.35
Average gross beta concentrations (pc/liter):	
Co^{60}	1,700
Fe^{59}	100
Mn^{54}-Co^{58}	240

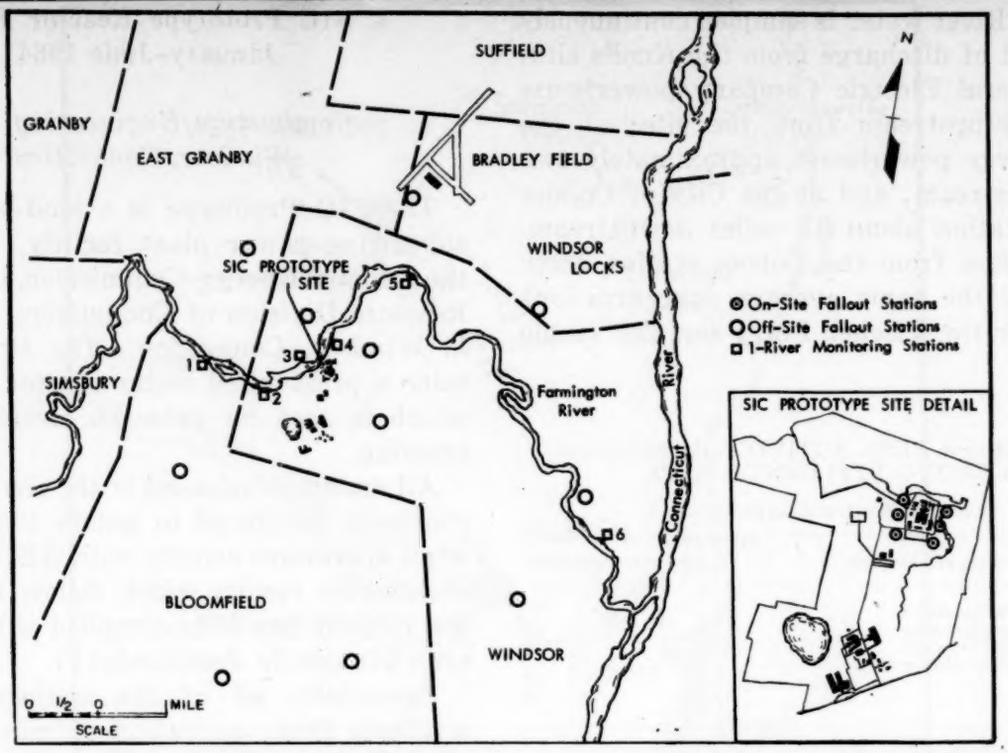

FIGURE 5. ENVIRONMENTAL MONITORING LOCATIONS, S1C PROTOTYPE SITE

Figure 5 shows the locations of 6 water sampling stations along the Farmington River and of 17 fallout monitoring stations. A more detailed description of S1C Prototype Reactor Facility and its control measures is available in the September 1961 issue of Radiological Health Data. Comparisons of the data for upstream and downstream samples appear in table 9.

Recent coverage in *Radiological Health Data:*

Period	*Issue*
July–December 1960	*September 1960*
January–July 1961	*March 1962*
July 1961–June 1962	*July 1963*
July 1963–December 1963	*June 1964*

TABLE 9.—BETA ACTIVITY IN THE FARMINGTON RIVER, JANUARY–JUNE 1964

Sampling station (figure 5)	Activity
Water (pc/liter)	
Upstream	[a] 18.1
Outlet	[a] 18.1
Downstream	[a] 18.1
Mud (pc/g)	
Upstream	26
Outlet	[a] 10
Downstream	[a] 10

[a] Equal to background.

REFERENCES

(1) U.S. ATOMIC ENERGY COMMISSION. Rules and regulations, standards for protection against radiation, Title 10, Part 20, Appendix B, Table 2. U.S. Government Printing Office, Washington, D.C.

REPORTED NUCLEAR DETONATIONS, MARCH 1965

During the month of March two United States nuclear tests were announced by the Atomic Energy Commission. Both tests were of low-intermediate yield (20–200 kilotons) and were conducted underground at the Nevada Test Site.